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THE JOURNAL OF

THE INSTITUTION OF PRODUCTION ENGINEERS

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Principal Contents :

MATERIALS HANDLING—Regional Conferences

MATERIAL HANDLING—A Job of Production Engineering
By Walter C. Puckey, M.I.Prod.E., F.I.I.A.

METHOD, MOTION, TIME AND MATERIALS HANDLING
By W. James Webb, A.M.I.Mech.E., A.M.I.Prod.E., A.M.I.I.A.

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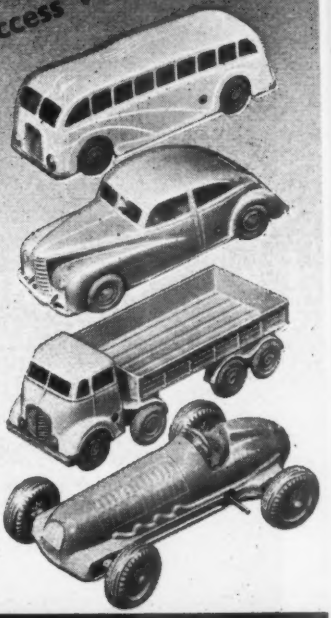

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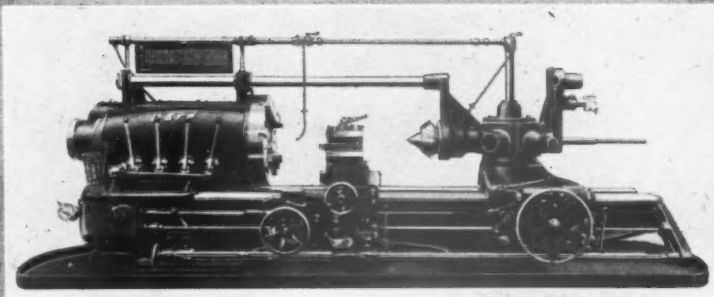

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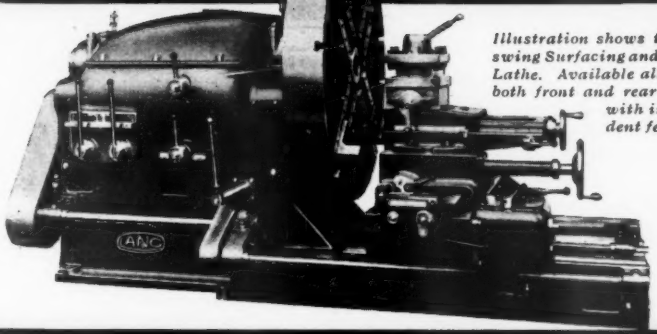

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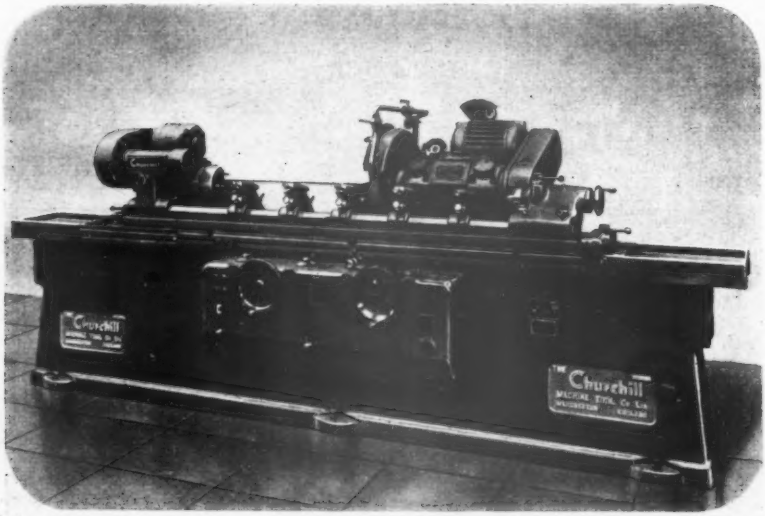

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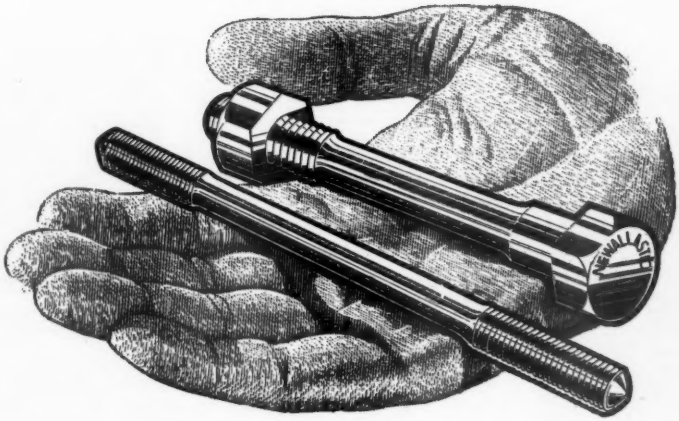

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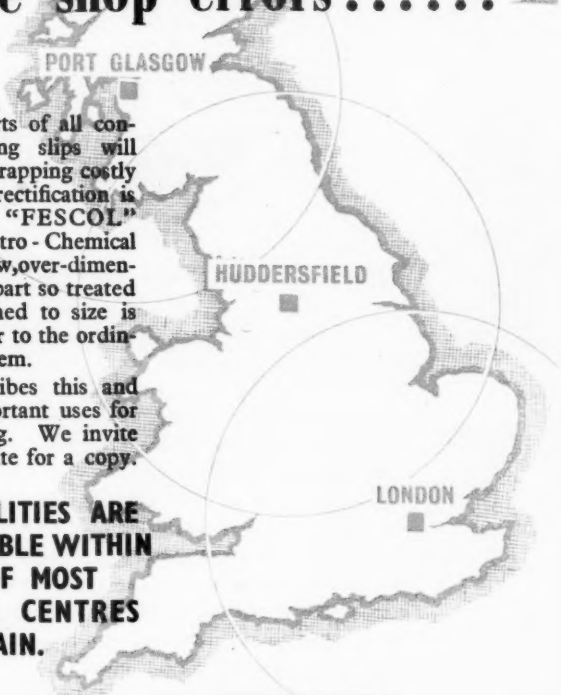

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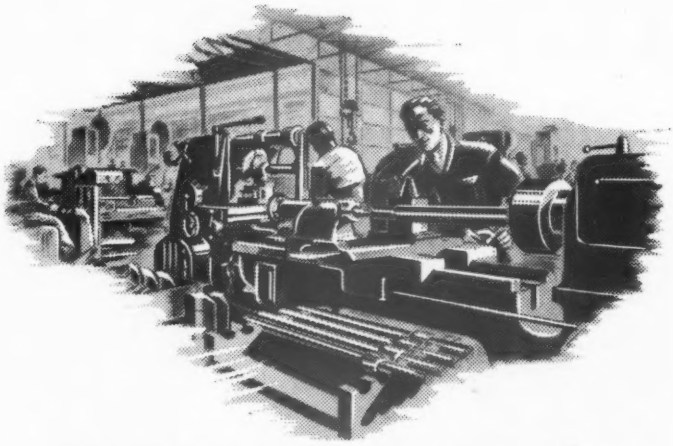

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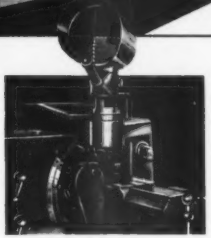
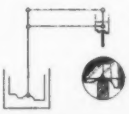


The combined microscope and projection screen is seen in the above close-up of the upper head on which can be noted a vernier for setting the wheel to grind an angle, producing clearances, etc., with a maintained form.



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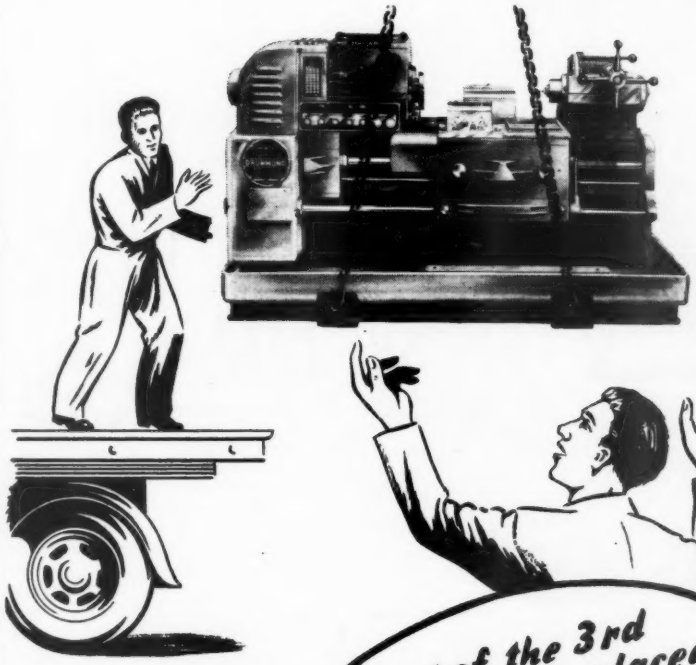

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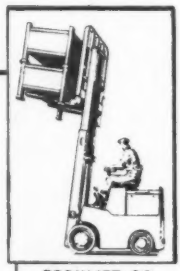
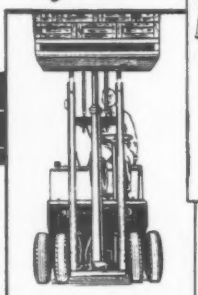


FORKLIFT 20



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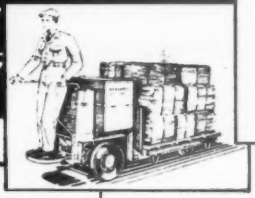

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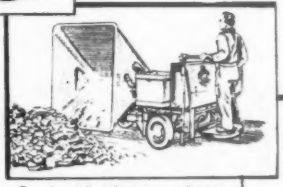
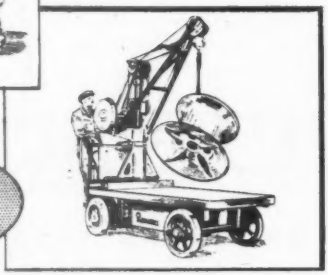


2-ton Truck with side tipping hopper



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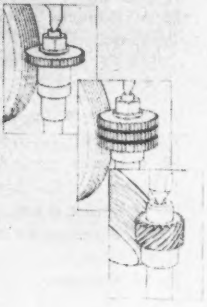

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Southern	J. W. Taylor, 44, Deacon Road, Bitterne, Southampton.
South Wales & Mon.	S. T. O. Davies, 4, St. Cadoc Road, Heath, Cardiff.
Sydney (N.S.Wales)	J. M. Steer, G.P.O. Box 1665, Sydney.
Western	A. Eustace, 19, Ferndale Road, Northville, Bristol, 7.
West Wales Sub-Section	H. P. Sanderson, I.C.I. Ltd., (Metals Division) Waunarlwydd, near Swansea.
Wolverhampton	W. J. Marshall, Moston Park, Lee Brockhurst, Salop.
Yorkshire	J. L. Townend, 26, Moor Allerton Drive, Street Lane, Leeds, 7.

Graduate Section Honorary Secretaries

Birmingham	J. Irwin, 132, Grestone Avenue, Handsworth Wood, Birmingham, 20.
Coventry	S. Hey, 112, Moseley Avenue, Coventry.
Halifax	T. Marsden, 6, Kell Lane, Stump Cross, Halifax.
London	R. T. Mustard, 47, King's Road, Woodham, Weybridge, Surrey.
Luton	C. S. Brewer, 144, Hart Lane, Luton.
Manchester	G. H. Armes, 14, Fairmile Drive, East Didsbury, Manchester.
North Eastern	G. D. Robson, 86, Dryden Road, Low Fell, Gateshead.
Wolverhampton	R. W. Tomkys, 30, Church Road, Bradmore, Wolverhampton, Staffs.
Yorkshire	J. Freel, 27, Roundhay Grove, Leeds, 8.

INSTITUTION NOTES

June, 1950

MEETING OF COUNCIL The next Meeting of Council will be held at 11 a.m. on Thursday, 27th July, 1950, at 36, Portman Square, London, W.1.

PRODUCTION ENGINEERING SUMMER SCHOOL, 1950 A limited number of vacancies is still available for the Summer School which will take place at St. Peter's Hall, Oxford, from Wednesday, 30th August, to Sunday, 3rd September, 1950.

Application forms and details of the programme may be obtained from the Head Office of the Institution.

TECHNICAL STATE SCHOLARSHIPS, 1950 As announced by the Ministry of Education in Administrative Memorandum No. 356 of 24th March, 1950, arrangements have been made to award 120 Technical State Scholarships in 1950 to students from Technical Colleges and other establishments for Further Education. These Scholarships will be offered to students to enable them to pursue full-time degree courses or courses of equivalent standard at Universities, University Colleges or establishments of Further Education. Such courses must normally lead to an Honours Degree or qualification of similar standing.

The Memorandum gives information concerning qualifications and conditions for entry, and full particulars concerning entry and method of application are given in an explanatory leaflet, Form 1 U.T. Intending candidates may obtain copies of this Form and also of Form 2 U.T. (Application Form for Candidates' Use) from Principals of Establishments for Further Education, or from the Ministry of Education, Curzon Street, London, W.1.

Applications must be submitted by candidates through the Principal of the Further Education Establishment concerned, and must reach the Ministry of Education not later than 30th June, 1950.

TECHNICAL APPOINTMENTS Applications are invited for three vacancies in the departments of Production Engineering and Mechanical Engineering at the Wolverhampton and Staffordshire Technical College. Salaries will be in accordance with the Burnham Technical Scale for Assistants with additions to the Scale for approved study or training up to a maximum of three increments; for degree or recognised equivalent, two increments; for First Class

Honours, a further increment at the minimum and two at the maximum of the scale.

One of the posts may carry an additional responsibility allowance of £100 p.a. At least one early appointment is desirable, but applications will be considered from candidates unable to commence duty before September, 1st, 1950. Full particulars may be obtained from F. Lonsdale Mills, Clerk to the Governors.

NEWS OF MEMBERS

Mr. L. G. Brown, Associate Member, is now Chief Engineer to Mansell, Hunt, Catty & Co. Ltd., London.

Mr. James C. Campbell, Associate Member, has been appointed Works Manager of Thomas White & Sons, Ltd., Paisley.

Mr. R. Ellis, Associate Member, is now Assistant General Manager of Britannia Engineering Co. Ltd., West Bengal, India.

Mr. A. M. Harrison, Associate Member, is now Works Manager for Harrtz & Bell, Ltd., Nairobi.

Mr. Robert Hutcheson, Associate Member, and Editor of "Machine Shop Magazine," is touring the U.S.A. and Canada, where he is visiting engineering firms and the Canadian International Trade Fair.

Mr. A. R. Northover, Associate Member, Works Manager of Hoover Washing Machine Factory at Merthyr Tydfil, has been appointed a Director of Hoover (Washing Machines) Ltd.

Mr. Ellis Shackleton, Associate Member, has been appointed Sales Manager for Dean, Smith & Grace, Ltd., Keighley.

Mr. P. J. Shipton, Member, is now General Manager of the Elms Works of J. Brockhouse & Co. Ltd., at Wolverhampton.

Mr. W. A. Smyth, Member, has been appointed Managing Director of W. G. Bagnall & Co. Ltd., Stafford.

OBITUARY The Institution announces with deep regret the death of Mr. D. Tiranti, A.I.Prod.E.

BOOKS RECEIVED "Modern Workshop Technology — Part 2. Machine Tools and Metrology." The Cleaver-Hume Press Ltd., London. Price 32/- net.

This, the second volume in the series to appear under the capable editorship of Professor H. Wright Baker of the Manchester College of Technology, is a symposium contributed by acknowledged experts in their particular sphere, amongst whom can be mentioned

A. J. Chisholm, H. C. Town, R. J. McL. Whibley, Dr. H. W. Swift, and L. W. Nickols, of the N.P.L.

All types of machines tools and machining processes are dealt with in the light of modern practice and research, and many specialised subjects such as surface measurement, technology of sheet metal drawing, broaching, lubrication, and so on are treated in a thorough way. (There is included a section devoted to Human Relations in the Workshop).

The book adequately serves as both a guide and a reference to teachers, research workers, and advanced students in the engineering industry, and whilst it cannot be considered elementary in the accepted sense, it nevertheless does serve as a useful introduction for persons seeking mature information on the subjects expounded.

A useful feature of the book is the bibliography given at the end of each article, whilst the method of numbering the plates and diagrams is to be commended.

A.A.J.F.

" National Certificate Workshop Technology " by T. Nuttall. The English Universities Press, London. Price 8/6d. net.

" Manufacturing Processes—Production " by S. E. Rusinoff, M.E. The Technical Press, Ltd., London. Price 42/- net.

" Manufacturing Processes—Materials " by S. E. Rusinoff, M.E. The Technical Press, Ltd., London. Price 40/- net.

Cutanit Cemented Carbide Tips and Tools. William Jessop & Sons, Ltd., Sheffield.

Institution Dinner

The Institution Dinner is to be held on Wednesday, **October 4th,** 1950, at the Dorchester Hotel, Park Lane, London, W.1., when the President of the Board of Trade will be the Institution's Guest of Honour.

Members wishing to attend the Dinner are asked to make early application for tickets. (Evening dress with decorations, or dinner jackets). An Application Form was enclosed with the May Journal.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

ISSUE OF JOURNAL Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

SECTION MEETINGS

The following meetings have been arranged for June, 1950. Where full details are not given, they have not been received in time before going to press.

June

13th **Wolverhampton Graduate Section.** A lecture on "The Effective Use of Material" will be given by Mr. L. V. Curley, Grad.I.Prod.E., followed by another lecture on "Effective Use of Materials in the Bolt and Nut Industry" given by Mr. M. A. G. Andrews, Grad.I.Prod.E. This meeting will be held at the Wolverhampton and Staffordshire Technical College, Wolverhampton, at 7.15 p.m.

19th **London Graduate Section.** A tour of Sweden has been arranged, to take place from 19th June to 1st July, 1950.

24th **Birmingham Graduate Section.** The Annual Outing is being arranged and members will be notified of full details in due course.

MEASUREMENT OF PRODUCTIVITY

Following the publication of their Interim Report last December, the Joint Committee of the Institution of Production Engineers and Institute of Cost and Works Accountants have been preparing for a wider extension of their work, and members may be interested to learn of the progress now being made.

In following up some of the points made in the Report, the Joint Committee will be investigating the complex subject of measuring productivity along a number of different lines as set out below :—

FORMULATION OF A COMPREHENSIVE TIME STUDY TRAINING SCHEME A special Sub-Committee has been set up under the chairmanship of Mr. B. H. Dyson to consider this aspect ; the Sub-Committee will include a number of individuals with special experience of Time Study practice. The Sub-Committee are considering the qualifications necessary for various grades of time study staff, and are examining work study training schemes at present in existence.

INVESTIGATIONS INTO SPEED AND EFFORT RATING As announced in the February issue of the Journal, the Joint Committee is collaborating with the Research Unit of the University of Birmingham led by Professor T. U. Matthew, which is making a survey of standards of consistency and accuracy ir time study rating practice over a wide field of industry throughout the U.K. The Research Unit intends to visit about twelve industrial centres to conduct investigations amongst several hundred concerns in widely varying industries. Section Hon. Secretaries and I.C.W.A. Branch Secretaries in the areas concerned are to be kept informed of this work.

INVESTIGATIONS INTO TIME STUDY ALLOWANCES The Work Measurement Research Unit hope to make a survey of time study practice with regard to allowances for fatigue and other factors, after the completion of their investigation into speed and effort rating.

MACHINE UTILISATION A special Sub-Committee has been set up by the I.C.W.A. members of the Joint Committee to plan a survey of machine utilisation in various industries.

USE OF PROCESSES FOR MEASUREMENT AND COMPARISON This research is being continued by the I.C.W.A. Sub-Committee. Any members who are particularly interested in any of these aspects of the problem, and feel they have a contribution to make, are invited to get in touch with the Joint Committee on Measurement of Productivity.

MATERIALS HANDLING

Regional Conferences

IN view of the importance of this subject, and its influence on industrial efficiency, the Institution of Production Engineers has been giving a great deal of time and thought to the study of Materials Handling, and is planning an extensive programme of lectures, discussion and development work for this year, with considerable research to follow. With these intentions in mind, a Materials Handling Sub-Committee under the chairmanship of Mr. W. J. Webb, A.M.I.Mech.E., A.M.I.Prod.E., A.M.I.I.A., has been set up by the Research Committee to co-ordinate the studies which will be undertaken by local Sections, and to prepare a comprehensive report on the subject.

In this connection a series of One Day Conferences has been arranged in various districts. The first two of these, held in Bristol and Coventry, met with enthusiastic support and following is a brief report on the proceedings.

BRISTOL The Conference held at Bristol was organised by the Western Section, and with Bristol as the centre, arrangements were made to include the Southern, Cornwall and Wales sections. The Bristol Conference commenced with a reception held in the Canteen of the Bristol Aeroplane Co., Filton, on the evening of Friday, 12th May, followed by a conducted tour of the Brabazon Assembly Hall and an inspection of Brabazon 1. This was a very successful function, and the Section is very grateful to the Bristol Aeroplane Co., for their hospitality and courtesy.

In a written foreword to the official programme, the President of the Western Section, Mr. R. S. Brown, referred to the subject of the Conference as being one of the most important factors to be taken into account by Production Engineers when planning the production of a factory, and much still remained to be learned on this subject.

The programme for Saturday, May 13th, was planned therefore, to deal with as many aspects of the subject as possible, and attract the greatest interest from those attending.

The main Conference, which was held at the Victoria Rooms, Bristol, was well attended and the opening address was given by Mr. Walter C. Puckey, Vice-Chairman of Council, followed by two members of the Anglo-American Productivity Council team on Materials Handling, Mr. W. J. Dimmock, A.M.I.Prod.E., and

Mr. J. R. Sharpe, who spoke of their own experiences and lessons learned on their American tour.

The morning session continued with two lectures—" Methods Study, Motion and Time Study—The Basis of Material Handling " by Mr. C. Cooper, and " Bulk Handling " by Mr. R. S. Thorpe. Opportunity for discussion was afforded after each address and speakers offered to reply by correspondence to questions which could not be adequately covered at the time.

The afternoon session opened with a film, " Prelude to Power ", by courtesy of the British Ropeway Engineering Co. Ltd., followed by two more lectures, " General Materials Handling " by Mr. H. P. Mott, and " Fork Trucks and Unit Loads " by Col. R. T. Hartmann.

The proceedings were summed up by Mr. Walter Puckey, and this highly successful Conference terminated with a well-deserved Vote of Thanks to all concerned with its organisation.

COVENTRY The success of the Materials Handling Conference held at Coventry on Saturday, 20th May, justified the somewhat unusual arrangements made by the Coventry Section, who are to be congratulated on their organisation and initiative.

By courtesy of the Board of Directors, the Conference was held at the Stoke and Ryton Works of Humber Ltd. Delegates assembled at Ryton, where they were welcomed by Mr. B. C. Harrison, President of the Coventry Section.

The opening address, by Mr. Walter C. Puckey, was read by Mr. D. Burgess in Mr. Puckey's unavoidable absence in America. Emphasis was laid on the economic aspect of mechanical handling, and the many features which made this approach to the reduction of overhead costs one which would appeal to all Production Engineers were outlined.

This was followed by conducted tours of the Stoke and Ryton factories where material handling methods covering a very wide field were examined. Whilst mainly applicable to mass production, many examples shown could readily be applied to smaller industrial concerns, not particularly concerned with quantity production.

Part of the tour included the highly mechanised foundry, which is planned on flow line principles. Manual handling has been reduced to a minimum, and in addition to mono-rail conveyors, pallet-type floor conveyors form the casting tracks, band conveyors carry cores from the core-blowers to the drying stoves, slat conveyors take castings through the fettling section, and roller conveyors are extensively used. The result has been a fivefold increase in casting production in the same area, compared with the old floor moulding output.

The delegates were conducted through the machine shops, where interest was centred entirely on the elimination of man handling or work from machine to machine, and the introduction of conveyors, trucks, and stillages. Attention was called to the opportunities available for reducing effort in clamping work in fixtures, and many other ways of simplifying the duties of machine operators. The use of conveyors for buffer stocks of work in progress was also demonstrated.

Another important aspect of handling which was particularly emphasised was inter-works transport, not only between the works of the organisation, but between the organisation and their numerous suppliers of components and details.

This phase of mechanical handling is closely related to the problem of storage, and many examples of efficient storage were shown which not only made full use of height as well as superficial area, but also of various devices for ensuring that material was handled speedily and with the minimum of man power. An interesting demonstration of the economic use of space was a conveyor which could store as many as 380 completed engines in the roof of a building ; in fact, the conveyor ran through the roof trusses.

In the erection bays, considerable use is made of conveyors of both overhead and floor types, the different levels being used to suit the convenience of the operations to be performed. Examples were also demonstrated of the use of conveyors to ensure that a time cycle was maintained.

Various ancillary operations within the Company, such as swarf handling, coal conveying, etc., were also brought to attention.

It was particularly noticeable that throughout all phases of material handling, attention was paid to the protection of work against damage.

A feature of the tour which attracted a great deal of interest was a demonstration of the use of the third dimension in laying out material handling schemes—a most important consideration by reason of the fact that much of the preliminary design of equipment for the purpose is done not on the drawing board, but by means of models or visual planning.

After the Works Tour, which included lunch at Ryton, the delegates reassembled there for the Brains Trust. The Chair was taken by Mr. W. J. Dimmock, A.M.I.Prod.E., who was Secretary of the Anglo-American Productivity Council Team which visited the United States last year to study mechanical handling methods. Also on the platform were Mr. W. M. Hiorns, A.M.I.Prod.E., another member of the Team, and representatives of several of the leading manufacturers of material handling equipment. This Brains Trust

dealt in comprehensive fashion with a number of questions on general aspects of mechanical handling.

The day's activities were summed up by Mr. E. W. Hancock, M.B.E., Member of Council of the Institution, and Works Director and General Manager of Humber Ltd., and the Conference concluded with tea at Ryton Works.

The Coventry Section is greatly indebted to the Directors of Humber Ltd., for generously providing facilities, and for the considerable help given in the organisation of the proceedings.

MATERIAL HANDLING-
A Job of Production Engineering

by WALTER C. PUCKEY, M.I.Prod.E., F.I.I.A.*

MY ASSUMPTION That the production engineer has, in the past, concentrated largely upon the operation of the productive units or machines themselves, and not upon the movement of materials between the machines.

MY PURPOSE (1) To show that the true production engineer must give greater consideration to the flow of materials between productive units, whether inside or outside the organisation. His activities start with the supplier of materials and end with the delivery of finished units to the customer.

(2) To show the advantages of good material handling, in many ways not always recognised.

(3) To suggest standards for more precise control of material handling.

You will see immediately that my message is directed to production engineers, although any other materials handling experts who wish to listen-in are welcome to do so. After all, we have been told by the Anglo-American Productivity Report on Materials Handling that good sales effort goes a long way towards conversion of the potential customer. Perhaps, therefore, my paper may provide you with further ammunition.

Let us start with three definitions.

(1) *Material Handling* is the movement of everything used in the company, including the people who work in it.

(2) *A production engineer* is one who is competent by reason of education, training and experience in technology and management, to determine the factors involved in the manufacture of commodities and to direct the productive processes to achieve the most efficient co-ordination of effort, with due respect to quantity, quality, and cost.

(3) *Production* is material in motion.

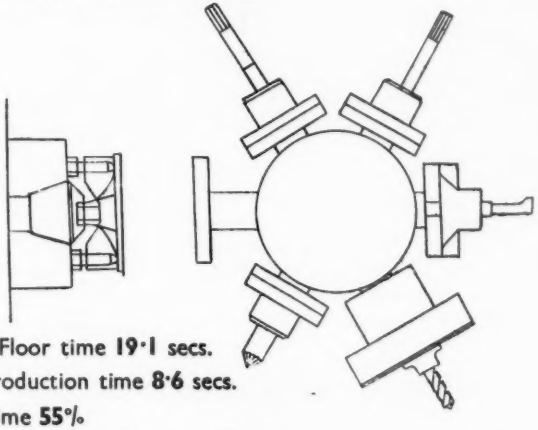
How many agree with my basic assumption that few production engineers have realised so far the full implications of material handling? A study of the papers and publications of the Institution of Production Engineers, the national body devoted to this technique, shows that over the last two years, to take only a short period, 12

* *Presented at the Mechanical Handling Exhibition and Convention, Olympia, June, 1950.*

papers on material handling have been presented to its 30-odd sections in several countries out of a total of 444 lectures. Only 2·7 per cent. Not really significant, is it? Yet, of course, this is understandable. The basic production unit whether lathe, drill, loom, rolling-mill or furnace is spectacular, often costly, and is the focus of attention of managers and visitors. If it is not in motion they ask questions; they rarely ask questions if the material being fed *to* or *from* the machine is stationary; in fact, many people think a good pile of work around the machine looks nice!

Production engineering, therefore, has developed on the machine and not so much around it. The technique of *production control*, which is concerned much more with material movement and less with machine movement, is still in its infancy, although definitely a subject within the I.P.E. educational syllabus. It is significant that in our own company more promotions to higher factory management have taken place from production control departments than from any other single department. These men cultivate a dynamic outlook towards material which helps them to widen their managerial outlook.

Layout of a Typical Production Unit



Floor to Floor time **19·1 secs.**
Actual Production time **8·6 secs.**
Waste Time **55%**

Fig. 1

PRODUCTION IS MATERIAL IN MOTION

On the production machine itself the production engineer must of course, be interested in *movement*. Fig. 1 shows a typical production unit layout, in this case a capstan lathe, which I have taken because a lathe is a basic machine in industry. Many other examples could be chosen in many industries. In this case

The Scope of a Typical Production Unit

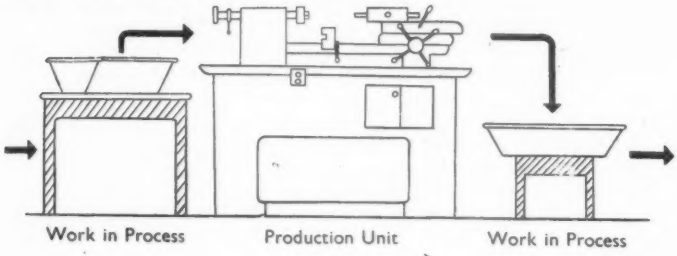


Fig. 2

we have a number of cutting tools acting, in turn, on a piece of material. The production engineer endeavours to minimise the waste time when, as he says, the tools are " cutting air ". Only when the maximum number of tools are in cutting contact with the work-piece is the machine performing its true function. Taking one of our typical jobs, the actual cutting time is only 45 per cent of the " floor to floor " time ; only 45 per cent of the machine value is being utilised.

This waste is worth concentrating upon and no production engineer can afford to neglect that sort of saving. It is all part of the handling problem. But is it all the waste we have ? What happens to the material before it arrives at the machine and after it leaves the machine ?

Fig. 2 shows a simple layout, including the lathe mentioned earlier. The production engineer usually directs his attention to the movement of material into the production unit, and after completion, out of it. He assumes too often that the material is at hand to put into the machine and will afterwards be taken out and placed on the floor, thereafter being removed by some person unknown.

What are the alternatives to the floor ? The answer depends on many things, including the size of material, the size of batch, the system of production control used, to quote only the most important. The material may be taken from an old tea chest filched from the goods inwards department (7*s*. 6*d*. deposit on it !). It may, after production, be dropped into another box labelled on the outside : " NOT to be removed from stores " ! The production engineer has probably provided an operation layout sheet detailing all the production operations on the material concerned, and this layout will include the tools, jigs, gauges, etc., to be used on each production operation. The chances are that the means of arrival at the machine and means of disposal from the machine are not specified. He is concerned with " floor-to-floor " time, and too often this is literally

true. It is picked up from the floor and goes back to it again What a good chance incidentally to coin a modern expression ! Perhaps " door-to-door " time would be more appropriate.

What chances also to plan alternative material handling. This may be in the form of a chute on each side of the machine, a standard tote box suitable for a fork truck, a dip in the overhead conveyor, or even, as in a most effective case in one of our own works, a smart " hand-to-hand " catch. Insistence on the means of material movement being specified by the production engineer will certainly lead to much more attention on his part to this vital matter.

Now let me expand our single production unit into the whole cycle of material movement as it concerns the average manufacturer, and don't forget that this cycle is present whatever the product, and can apply to office as well as factory activities. It includes also the people who take part.

Fig. 3 shows such a complete cycle, again including our basic production unit (Figs. 1 and 2). Just consider the frontiers of your company. Surely they start in the works of your material supplier and cannot end until the finished product reaches your customer. In many cases they extend through to further customers beyond the first. So, therefore, we can diagrammatically express material movement as shown in Fig. 3, and in doing so we extend our internal material handling to the external sphere. Production engineers may well say at this point, " Do you mean that we must concern ourselves with such things as external transport, packing of materials and products ? ".

Well, there are precedents. Many production engineers are accustomed to discuss with their material suppliers such problems as quality, inspection specifications and, in some cases, quantity problems such as rate of delivery. Generally, however, the production engineer is not encouraged, neither does he encourage himself to have continuous contact with his company's suppliers, much less its customers. Yet, is it not logical that these contacts and

The Scope of Production

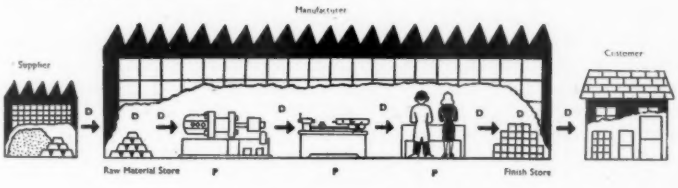


Fig. 3

interests should be built up? The supplier and the customer have a strong mutual interest with him in quality, quantity and cost. If the production engineer concerns himself with material movement he is interested in the material as it arrives at his factory. As it arrives, so it has left the supplier, and good unloading means good loading. Logically, therefore, external handling becomes just an extension to his internal handling problems. And so he asks himself, "Why should there be all that waste time in loading and unloading at his end?" "He pays for it." "Why should not his goods inspection be regarded as a potential production unit?" . . . and "Why should not the raw material stores offer a first-class opportunity for applying material control techniques?" All the skill he devotes to the existing problems of production engineering are equally applicable to these operations. All these operations are just as logical a part of his operation layout sheet as the machine operation normally concentrated upon. When I see all the waste of human effort in the many uninspiring jobs of moving material from a supplier to the first productive operation I am appalled, and the first step towards improving this is to make these operations the responsibility of those technically trained men who are already concerned partly with the same sort of work. They are the production engineers.

Production is Material in Motion

If we now consider the customer end of the business, we realise quickly that moving the responsibility for the finished product into his orbit gives the production engineer an interest in packing. Because we are an exporting nation, that means packing for home and abroad.

What justification is there for the production engineer to interest himself in packing? In most cases he is obviously interested until the final job is assembled and has passed its test. But is it the complete job at that stage? More and more, for instance, the packaging of a product is part of the product, a selling feature of it; this certainly is true in the export market. More elaborate arrangements will have to be made to pack as part of the productive process rather than as an ancillary job done by miscellaneous people in the despatch department. The finished stores will be stocked with packaged products and the handling and stock control problems will be revised accordingly. To-day the modern production control department handles packaging material just as it handles other materials used on the product. Why, therefore, should not the production engineer regard the packing and disposal of the product as a logical conclusion to his activities?

While writing this I read an interesting article* on the production and delivery of prefabricated American houses. Special delivery

* *Transport Management, 15th January, 1950.*

trailers were designed and moved by a conveyor past the loading stations. To quote the article . . . " The trailer actually performs a production function because it is a moving collection station, and *the loading line is considered a production department.*"

Returning to Fig. 3 we see the production engineer's real scope. So far he has generally devoted attention only to those productive units marked " P " ; in future, we hope that he will find equal possibilities in dealing with those activities marked " D ".

What practical steps can he take to improve these wider activities? I believe the best way is to focus greater attention on them. In his present sphere the production engineer focuses attention largely through the " operation layout " which, as I said earlier, is usually, if available at all, devoted only to basic production operations. It may not even include inspection activities, let alone handling. Fig. 4 shows such a layout sheet for the simple machining job shown

Operational and Tool Layout

Material Data : *Aluminium Alloy No. 11.* Fan Body - Part No. 60908

Operation No.	Operation	Machine	Tools Data
1	Diecast	Reed Prentice	J31359 D Die
2	Form, Bore and Ream	Capstan	Pictorial Layout
3	Assemble Fan Eye	Assembly Bench	J29178 D Fixture

Fig. 4

in the previous illustration. Such a layout assumes that the materials progress themselves from the supplier into the stores, through the factory and finally to the customer.

Now let us consider a simple addition to this layout chart. Fig. 5 shows the same job but with the addition of " movement " operations. Not only is more information given about the methods of moving the material, but what we might call " flow footage " is shown indicating how many feet the material or product travels in its journey from A to Z. I thought our own company was fairly good in handling problems, but when I saw a few examples drawn up from actual practice, I was not so complacent. " Time is money " so we are told ; space and distance are also money, in more ways than we realise. A much more detailed handling layout is shown in the Anglo-American report. It certainly makes you think.

Operation, Tool and Movement Layout

MATERIAL DATA—Aluminium Alloy No. 21 FAN BODY—Part No. 60908

Operation No.	Operation	Machine	Tools data	Handling	Internal movement
					ft.
1	Unload ingots at Foundry sub-store				
2	Transport to diecasting machine			Truck No. 1	100
3	Diecast	Reed Prentice	J31359D Die		
4	Move to checking stage			Chute	5
5	Inspect 100 per cent				
6	Transport to capstan			Truck No. 1	140
7	Form, Bore and Ream	Capstan	Pictorial layout		
8	Transport to checking bay and check 100 per cent			Truck No. 1	110
9	Transport to first floor			Lift No. 3	260
10	Assemble fan eye	Assembly	J29178D Fixture		
11	Load to run-in rack		R1463 Rack		10
12	Inspect, test and pack			Carton— Part No. 68736	10
13	Transport to warehouse			Conveyor No. 20	200
14	Load to lorry			Conveyor No. 36 and chute	150
15	Transport to customer			Lorry	
					985

Fig. 5.

Fig. 6 reproduces a diagram I embodied in a paper on management in 1948. It shows how much time was occupied in processing a typical batch of work through a factory. You will readily observe the very small time occupied on actual productive work and the tremendous amount of waste time where the material is literally " on the floor ". Here we see the connection between time, distance and money. Long distances travelled by men and materials between operations are not always avoidable, but they do represent idle money ; long times elapsing between production operations also represent idle money. " How much money " we shall ascertain later.

Progress of Code No. 600017, Support Yoke

	Process time per piece hours	Time in store or waiting on floor
Material ordered 18/7/46		
Material received 16/1/47		
Material issued to shop 11/11/47		10 months
Material on floor		48 hours
Crop, 13/11/47	·002	
Wait between operations		96 hours
Form	·003	
Wait between operations		24 hours
Pierce	·003	
Wait between operations		48 hours
Final form	·002	
Wait between operations		336 hours
Degrease	·050	
Cadmium plate	·031	
Wait on floor for usage on assembly line ...		240 hours
Assemble to cleaner, Inspect, test, pack	1·000	
Convey to stores	·220	
In stores waiting despatch		5 hours
	1·311	797 hours

SUMMARY

Material stored	10 months =	7,200 hours
Waiting time		797 hours
Actual time on process		1·3 hours
		7,998·3 hours

$$\frac{\text{Process time}}{\text{Total time}} = \frac{1{\cdot}3}{7{,}998{\cdot}3} = {\cdot}0016 \text{ per cent.}$$

Fig. 6

THE ADVANTAGES OF GOOD MATERIAL HANDLING

I have tried, so far, to make out as good a case as possible for the production engineer to devote his attentions to a broader sphere of operations. What are the advantages likely to result from this greater concentration on handling problems? Let us try to list the more important. If any are left out you can, no doubt, fill the gaps.

Some Advantages of Good Material Handling

(1) Minimises need for communication roads, paths, gangways, etc., and enables space to be used for more productive work.

(2) Makes more use of "third dimension", i.e., space above ground level.

(3) Speeds up flow of material between works, departments, machines, operations and processes.

(4) Reduces value of work-in-process through (3), thus reducing financial investment.

(5) Enables shorter delivery times to be achieved through (3).

(6) Enables more flexible schedule of production to be achieved (i.e., changes in design, pattern, etc., to be accommodated) through (3) and (4). This particularly helps export requirements.

(7) Reduces handling damage in stores and work-in-process.

(8) Improves quality.

(9) Reduces unnecessary fatigue and allows effort to be more productive.

(10) Reduces accidents.

(11) Creates faster "rhythm" of work.

(12) Assists supervision and production control through reduction of work-in-process and more orderly disposal of material.

(13) Reduces man-power portion of overheads.

(14) Minimises need for "shop labourers" who are in short supply and whose work is not usually attractive.

(15) Encourages pride in work among users of equipment.

(16) Encourages ancillary operation such as pickling and heat treatment to be regarded as flow-line operations. This usually enables the equipment to be redesigned for better and cleaner operation in the regular manufacturing line.

(17) Attractive to visitors.

This looks a very imposing list, doesn't it? More important still, it shows advantages to every department in the company. The

production engineer, the time-study engineer, the production controller, the chief inspector, all have obvious interests. The financial department should be easily persuaded to invest in such a cost-saving technique. The sales manager is, or should be, tremendously interested in the flexibility of schedule and speed of deliveries. Material handling is literally a technique which more than almost any other single technique spreads its advantages over nearly every activity in the company.

Let us make a summarised list of the advantages I have just given and see what departments are *principally* interested in one or more of them. It is shown overleaf.

Now let us examine in a little more detail, the list of advantages given earlier.

(1) *Conserves space.* Fig. 7 is an orthodox layout prepared by an unimaginative engineer as a sort of picture frame within which he then proceeds to plan his production flow. Take a rectangular factory of 30,000 sq. ft. and you immediately allow 15 per cent of total space for main gangways alone; the subsidiary gangways may amount to much more.

An even more important waste of space in the orthodox layout is between the production units themselves. Taking an engineering machine shop as an example, it is possible to find only 30 per cent of the total space taken up by the machine area, plus worker requirements. Some outstanding examples of floor-space utilisation are to be found in the U.S.A., where material handling between machines is brought to a fine art. When asked how much space to allow between machines, they remember the advice given to the young man who wanted to know about being married—the answer was "don't".

Orthodox Layout of Factory

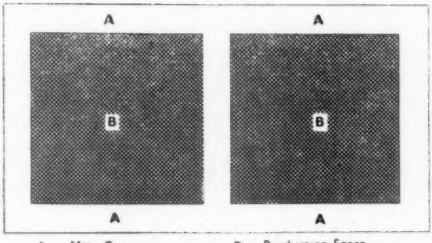


Fig. 7

The machines are placed in such strategic relationship to each other that little handling of major components is necessary. Don't remind me of the limitations of jobbing shops and other factories where there is little flow production. It's surprising how much scope there is for eliminating unnecessary handling in every company if you are really interested.

(2) *Uses "above-the-floor" space.* Perhaps the best way to emphasise this advantage is to remind production engineers of the

Interest Scope of Material Handling

ADVANTAGES	THOSE PRIMARILY INTERESTED								
	Worker	Mangr.	Chief Inspr.	Personnel Officer	Safety Officer	Prod. Eng.	Cost Control	Purch. Officer	Sales Mangr.
1. Conserves floor space		X				X			
2. Uses above-the-floor space		X				X			
3. Speeds work flow		X					X		X
4. Reduces financial and material investments		X					X	X	
5. Shortens delivery time									X
6. Makes production schedule more flexible						X		X	X
7. Reduces handling damage	X	X	X		X				X
8. Improves quality	X	X	X			X	X		X
9. Reduces fatigue and increases productivity	X	X		X	X	X	X		
10. Reduces accidents...	X	X		X	X				
11. Creates better rhythm	X	X		X	X				
12. Assists supervisory control		X	X			X			
13. Reduces manpower overheads				X			X		
14. Fewer shop labourers				X					
15. Encourages pride of work	X	X	X	X					X
16. Encourages redesign of production units...	X	X		X	X	X			
17. Attracts visitors	X			X	X				X

NOTE : It can be argued that some of the executives above have an interest in *every* advantage shown.
X indicates only where a special interest is shown.

old puzzle, "How can you lay three matches over three other matches which are arranged on the table as an equilateral triangle? No match must be laid *on* any other, neither must any match cross any other". The solution is shown in Fig. 8 where you see that we rear the other three matches up in the air to form a sort of wigwam. You use the "third dimension". It is a variation on the answer I always give when someone says, "You cannot get a quart into a pint pot". You can if you knock the bottom out of the pot and pass the quart through it!

Using the Third Dimension

Fig. 8

Production is Material in Motion

(3) *Speeds up work flow.* If the little slogan just above this has been thoroughly accepted, you will agree that material at rest is no use to you, once you have bought it. The immediate objective is quickly to fabricate it and dispose of the finished product. If you gaze again upon Fig. 5 you will agree that there is plenty of scope even in a company which prides itself on good material handling.

In one of our factories the winding department, prior to the war, found it impossible to have as work-in-process less than five times the weekly output of wound units. To-day, by better handling and layout changes, it has been found possible to speed up the "throughput" to such an extent that with a weekly production greatly exceeding pre-war a "work-in-process" ratio of only 2 to 1 is maintained.

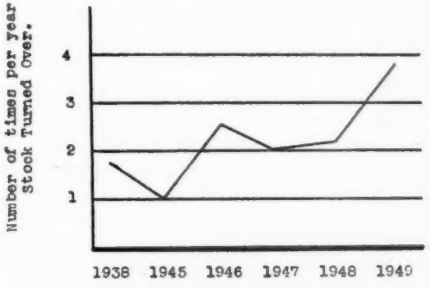


Fig. 9

(4) *Reduces financial and material investments.* Any proof the production engineer can furnish which will enable him to save more money than he wants to spend on equipment is always welcomed by the cheque signers. Let us look at a few examples of material investment in terms of money.

Fig. 9 shows the changing relationship between stock and turnover in one factory. If you reach a turnover ratio of nearly 4 to 1 you are doing pretty well in most companies. Check your own figures against these ; you will probably find that more attention to this ratio will force you to concentrate on better handling. The financial economics give good scope.

Another investigation I have made into a wide group of firms shows the following ratio :—

Total stock value / Total capital resources	=	1938 28 per cent	1948 47 per cent	Increase per cent 67 per cent

These figures are not conclusive but they do tell us that a lot of money is involved in material stock, mostly just lying around the floor. The financier might well adopt our slogan and say that profit is money in motion. As material is money, then profit comes from material in motion.

The following extract from the *Economist* is interesting. " *For 690 companies whose reports were issued in the last quarter of 1949, stocks show an increase from £316·0 million to £338·3 million. . . . For the 690 companies as a whole, stocks now represent just over 90 per cent of their net current assets.*"

We find also that stock and work-in-process combined exceeds greatly the proportionate pre-war figure of these companies. There have been many reasons for this increase in the last ten years. Material deliveries have been spasmodic, and the manufacturer has played safe by stocking up whenever possible. Don't forget incidentally that greater stock means greater floor space to hold it, an expense not always realised, particularly in the loss of potential *productive space* it involves.

Finally, to all concerned, remember the slogan : " Handling adds cost but no value to the product."

(5) *Shortens delivery time.* Look once again at Fig. 6. Here you see that the time spent by the individual component on production machines is only ·00016 per cent of the total time the component (or its material) is waiting in stores or between operations. How much faster we can put material through by better handling.

One of the most serious complaints we have to overcome in selling to America is the length of our delivery times. If we can't get more labour, more space or more production machinery, we can at least concentrate on quicker " through-put ". Carry out a few checks in your own company and ascertain where red lights impede the flow.

(6) *Makes Production Schedules more flexible.* If you speed up the flow of production you can put through *more* production, or alternatively you have more time available, if required, to modify the

schedule by putting through variations of product. I, as a mass-production enthusiast, am naturally not enthusiastic about too much variety in production and, confidentially, it is not always advisable to make it too easy for your sales manager to alter the delivery schedule, either by time or type. As managers, however, we know that, particularly in the export field, we cannot always dictate to customers and, in any case, the dollar market will only be captured by doing what the Americans do at home. If they want *this* product at *that* particular time they expect to get both. Generally, inflexibility of production is caused, not by any ill-will towards the customer by the production engineer, but by the normal time thought necessary for planning the job, getting the material and flowing it through the departments. If he can allow less time by increasing " through-put " he will quote less time. It is surprising how much flexibility can be built into a layout if you study the variables thoroughly. This may force you to consider the handling of tools and equipment as well as the production material. For instance, the basic machines, whether lathes or looms, may be capable of producing many jobs and the difficulty is in re-tooling and re-setting. Good stock-keeping, overhead runways and lifting devices may speed up the supply and fixing of tools and equipment. It may often pay to have whole machines available in reserve for special jobs, such machines being moved by easy handling into the line-up. While writing the paper I have had further confirmation of the possibilities here from a friend who recently took over the management of a large engineering company making heavy products. He was walking through a machine shop and saw in one area three skilled men and three expensive machines waiting for the same crane. Just think of the overheads piling up for lack of adequate " overheads ".

In another part of the shop he saw an 80-ton crane being used to lift the chuck off a lathe. How simple it would be to provide local lifting arrangements for each machine.

It pays also to analyse the factors concerned in putting through rush jobs, and then to consider more fully how many of them can be improved by making more permanent provision in the basic layout. In the achievement of this objective, handling methods, particularly of the ancillary equipment itself, may play a valuable part.

(7) *Reduces handling damage.* Less stores and work-in-process obviously means less damage. Look at Fig. 10 which was taken in one of our stores before reorganisation. How *can* you avoid damage when this condition prevails ? I can only say that in one factory where handling has been given greater attention, the percentage cost of scrap and re-operation has fallen by about 20 per cent in three years. It may be coincidence but I think not. You remember the story of the London lady who asked the railway porter whether

Fig. 10. *Too much stores can mean unnecessary damage*

her trunk would arrive safely at Glasgow. He threw it on the ground saying " This is what it will get at Leicester ". Throwing it on the ground again he repeated, "This is what it will get at Doncaster". Once again, doing the same thing, he said, " This is what it will get at Carlisle ". At that juncture the trunk fell to pieces. " No lady," he said, " it won't reach Glasgow " ! Let's try to eliminate the crashes at Leicester, Doncaster and Carlisle.

(8) *Improves quality.* This may not be easily apparent ; it is certainly more applicable to quantity production than to jobbing work. Let us give a few examples from the former field. Certain components have to be enamelled to a high degree of finish and durability. How difficult to ensure that the right sequence of operations is used on every part ; that the right speed and time of dipping or spraying is used ; that the right time is given in the oven ; and so on. Yet how closely controlled each of these can be if the job is mechanised.

Or let us take a varnish impregnating operation on an electric armature. Methods now available control the dipping, temperature, and time on a continuous basis.

Many other examples could be quoted but they will all have something in common. They make it more difficult to forget a necessary

operation, to scamp work or to perform out of sequence an essential operation. They take out the guesswork which is at the back of most faulty work. Even the very job of quality inspection can be mechanised to check by sequence all the points required in a good product.

A further great advantage is that mechanised production and inspection speeds up the flow of work, which in turn means that rejections become known more quickly to those responsible. They can, therefore, apply corrective measures more promptly.

(9) *Reduces fatigue and increases Productivity.* The last few decades have seen a gradual shift from manual to machine labour. Gone are the days, except on the sports field, where sheer physical slog is regarded as a virtue. Man's ingenuity has been devoted more to controlling power, which enables him to do far more than he could possibly do without it. Nowhere more than in agriculture is this trend seen, and industry could learn much from the farmer.

"More power to the elbow" by getting more horse-power per unit of man-power is particularly significant when applied to handling problems. When I see someone pushing a heavy truck along I am reminded too vividly of the remark passed by the man who was asked why he pulled his wheel-barrow instead of pushing it! There is no sense in the continuous manual lifting of material to a machine; many women, for instance, lift several tons a day. Perhaps, if the paper work we normally handle weighed more, we should be more sympathetic to those human cranes who are to be found in many industries.

A recent writer* points out the startling fact that comparing horse-power in terms of electricity at 1d. per unit, and man-power at 3s. per hour, it takes about 10 men to do the work of one unit or an expense ratio of 400 to 1.

Less physical fatigue may certainly pave the way towards greater useful productivity.

(10) *Reduces accidents.* I told a story last year which is worth repeating, as it illustrates this section without further comment.

Returning from a trip to America some years ago, I walked into one of our factories and saw a nice poster on the safety board. It was designed by the National Safety First Organisation to which we subscribe. It warned workers against rupture by showing the right and wrong way to lift a heavy weight. I could not help reflecting that in many American plants where the handling accident rate was low, they probably didn't subscribe to such a body or display such nice posters. They bought a hoist instead!

An analysis of accidents shows that the number attributed to falling over materials is very high. Good handling promotes good housekeeping which is a very good accident preventative.

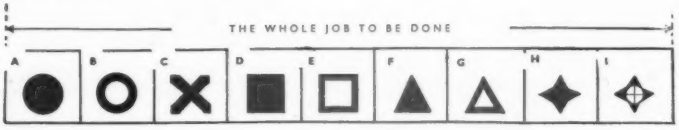
* *L. Wolliston. "Industry", January, 1950.*

(11) *Creates better rhythm.* A story in a book called " F.O.B. Detroit " comes to mind here. A foreman in a Detroit car factory found that the workers on a certain assembly line set their speed by a belt fastener clicking over a pulley just above the line. He increased the number of clicks per minute and up went the speed of work ! It's a good story, but has elements of truth. Watch an electric train coming into and leaving London Bridge Station and note the slickness with which porters and passengers move. Then watch the lethargy surrounding the steam train in the same station. Speed begets speed and an appearance of ordered movement inspires all to keep up the pattern.

The conveyor-line type of layout encourages production engineers to plan the job more effectively ; they are forced to break the production activity into smaller elements with the advantage that each element is likely to be given closer study.

Some people complain about the soullessness of modern mass production where each worker is supposed to perform one elementary task day after day. This is not necessarily true ; it is true however, that you can use some advantages of mass-production technique on batch or jobbing production. The mass-production technique usually involves breaking the job to be done into small elements. It is possible, however, " after taking the job to pieces " to re-assemble the separate " pieces " or elements into whatever suitable combinations the circumstances require. Let us look at Fig. 11.

Taking the Job to Pieces



A.B.C. etc. are individual elements into which the whole job can be analysed.

They may be performed individually (Mass Production)
They may be performed in groups (Batch Production)
They may be performed as a whole group (Jobbing Production)

Fig. 11

The output of complete jobs, if fairly large, may be obtained by each individual worker performing a small element, and then passing the job rapidly to another worker performing the next element, and so on. This certainly enables almost an imbecile to perform each elemental job, but it has often been carried too far,

resulting in much material movement per worker. The ratio of work-in-process movement to productivity is too high, and the monotony aspect unduly created. How advantageous it is, however, to *plan* the production by element wherever possible. Only this way can you isolate and study the common elements over a wide range of jobs, which is a valuable aid to those who estimate time and cost values.

Now you can "re-assemble" the elements not only in the sequence A.B.C.D., etc., but in any combination you find most desirable. It's like shooting a film; the final scenes may be taken first but the whole film is finally made up in correct sequence.

The operation layout shown earlier (Fig. 4) has, for a *very* simple job, been broken down into individual operations. The sequence shown makes it necessary for the job to travel 985 ft. before it is finished. Rearranging the sequence may reduce this considerably. One of many such improvements I remember in our own company required originally 20,000 components per week to travel 1,648 ft. on three floors before completion. To-day 30,000 of these parts travel only 726 ft., thanks to a rearrangement and regrouping of the elementary operations.

(12) *Assists supervisory control.* Consider the job I have just quoted. It passed through several departments on different floors in its fabrication. How difficult for a supervisor, whether of production or control, to know what was happening. The job of making schedule was extremely difficult, the stock-taking was complicated and individual responsibility, which is the keystone of supervisory success, was weakened. To-day, a compact layout, with most operations performed in a group under one supervisor, has eliminated the job from the shortage lists.

You will say this is impossible on many jobs. I agree, but it is possible on far more than you think. Study your shortage lists over the last year and those items most consistently on it are likely candidates for similar treatment. There are many other ways, depending on the product, by which the supervisor can be helped. Buffer stock checked by conveyor capacity, automatic counting to check output, and pre-set movement of materials come to mind as examples.

Production is Material in Motion

(13) *Reduces "man-power" overheads.* Variable overheads comprise two principal components: manpower and indirect materials or equipment. Wise investment in the latter more than returns advantage to the former. If, as I hope, full employment is maintained then every investment in equipment which enables manpower to be directed to more productive work is desirable.

Managers certainly need proof that the investment is a commercial

proposition, and it is here that production engineers require more training. They often present the case badly, and in this are not always helped out by the suppliers of handling equipment. It is surprising how much a man costs per year. He must be advertised for, selected, engaged, fed in the subsidised canteen, and, of course, paid. This amounts to hundreds of pounds per year at the least, and any engineer who cannot make out a good case on paper for saving essential manpower should really take a lesson in public relations. Don't forget that top management isn't obtuse by nature. It merely insists, and rightly, that subordinates prove their case.

(14) *Fewer shop labourers.* Any physical effort which could be re-directed towards better productivity is a waste. Any person failing to make use of more productive equipment, which is also probably less tiring than the existing method, is failing in his obligations to his fellows, quite apart from being something of an idiot.

Under certain circumstances, hard physical work may be gloried in, but anyone who watches a milkman or shop labourer pushing a heavy truck would have to be highly romantic to find other than lunacy in it over a long period. To-day is the era of " new names for old occupations ". Let our labourer become up to date by being renamed transport assistant or internal truck driver. Anything which can be done to get away from names or habits which perpetuate lack of pride is a good thing for people, quite apart from economics.

Let me utter one warning here, however, and this might be stated under :—

(15) *Encourage pride of work.* Most men like to control machines; between the ages of one and 100 we are thrilled by mechanical toys ; we enjoy riding cycles or driving cars. In our own company we have much proof that thousands of men like to operate electric cleaners or washing machines, aided, of course, by the subtle encouragements of their wives !

Similarly, in our work we like gadgets, whether they be automatic door openers or a fork-lift truck.

Why not, therefore, capitalise on this human trait as much as possible by giving men mechanical aids when possible. They like to use them, they like to be seen operating them, explaining how they work.

There is one extremely important consideration, however, to bear in mind when you consider man's reaction to mechanisation. In the mind of many a man rages a conflict between pleasure in using the machine and doubt on the economic reaction to his earning capacity. How often have we heard of strikes arising from the introduction of a new labour-saving device ? The reaction of

the strikers is not hard to visualise ; first of all the new device is likely to upset violently the established customs of the group or individual in it ; secondly, it may throw men out of work, or at least cause them to be transferred to other less attractive work. I think you and I would have the same reaction in similar circumstances. How can we remedy this state of affairs ? There are at least three ways. First of all, we can create and maintain an atmosphere of modernisation in our company. Men who are accustomed to seeing new layouts, new machines, new ideas continually encouraged and installed will more willingly take part in the change. This is a very important argument indeed and it will be a sorry day when taxation and other financial doubts cause firms to discourage *constant* modernisation. It stultifies imagination as well as mechanisation.

Secondly, we must ensure that drastic reduction in individual earnings is avoided during the change-over. After all, the company will get a long-term benefit and it's usually worth while making temporary arrangements which will " ease-in " the new conditions.

Thirdly, make certain that the minimum of labour adjustment is necessary *after* the introduction of the new equipment. Every man made redundant is a further argument against mechanisation, therefore before you make the change see that you have *less* labour on that line or group than you really want. See that those on the job *want* more help to achieve schedule.

(16) *Encourages re-design of production units.* Let me give you an example. A part is processed through a machine shop where the sequence of operations is reasonably good and then it requires heat treatment. In most firms this means that it is taken some way to a specialised department where all the heat treatment is done. Now consider a modern refinement where the design of special heat treatment equipment, such as high-frequency machines, enables these machines to be *placed in the production line.* The advantages are obvious. These new machines are usually quicker, they are certainly cleaner, and the material is handled and controlled more easily.

A variation on this procedure is to re-design a machine so that it may perform a group of operations instead of, say, one only. A recent example is a boring machine which now has facilities for some drilling spindles to be attached to it. A component which formerly moved in batch formation from boring to drilling now gets both operations performed simultaneously and handling is much improved. There are obvious limitations to this procedure but, even under quantity production methods we can do much grouping of operations around a basic production unit.

A further variation is to consider " production by product " as an alternative to " production by process ".

This raises a very big issue which cannot be elaborated here. Briefly, however, if you have the majority of work on a certain component done in one department, then it might be advantageous if it has only a small amount of other departmental work to be done on it, to move the production unit from the latter to the job, instead of moving the job to the unit. You must obviously apply this to your own conditions, but we employ it frequently and if there is a fairly good flow of work it is often far easier to move a machine once into another department, rather than continually to move batches of work away from the main department.

(17) *Attracts visitors.* Perhaps you don't encourage visitors. In our Company we entertain thousands a year in various factories and " watching the wheels go round " is a favourable occupation.

I remember years ago seeing trips by motor boat advertised to show visitors at Lake Erie, in America, how the large ore boats were loaded. I was one of thousands who were thrilled !

Material handling plays a most important part in visitor-appeal ; in fact, I've often considered whether it would be worth while having a special conveyor to take round the visitors !

STANDARD OF CONTROL

You may have already reached the conclusion that I am a material handling enthusiast. I am, but only if it pays. Better handling techniques have a much greater scope than most of us imagine, but don't let us lose a sense of proportion. *The most effective approach to material handling is to eliminate it,* and the production engineer should approach such a problem in the same manner as the time-study engineer approaches a job. " Is this job really necessary at all ? "

In any case, the more controls that are available within reason, and the better the measuring sticks used in these controls, the more satisfied we are that the schemes submitted are sound investments. Let us look at a few controls we can use. Here is a list of the more important :—

(*a*) The ratio of turnover to stores stock.
(*b*) The ratio of turnover to work in progress.
(*c*) The ratio of stores stock to work in progress.
(*d*) The average " through-put " time of a job.
(*e*) The average footage travelled by a job.
(*f*) The ratio of delivery costs to turnover.
(*g*) The ratio of packing costs to total cost of product.
(*h*) The average number of items on shortage lists.
(*i*) The achievement against quoted delivery times.
(*j*) The ratio of trucking cost to total cost.
(*k*) The ratio of stores cost to total cost.
(*l*) Utilisation of floor space per unit of turnover.
(*m*) Horse-power per worker utilised.

Of one thing I am certain ; cost reduction can only come from cost analysis. I said earlier that if you can segregate cost you are on the way to doing something about it, and overheads generally get out of control because they are not analysed in such great detail as direct costs. They represent the " bucket " into which we toss all doubtful categories.

If the technical press, the Institution of Production Engineers and the Institute of Cost and Works Accountants could encourage publication and comparisons between various companies on the control figures shown, they would do much to change opinion into fact.

SUMMARY Let me briefly, once again, review the high lights of this paper.

First of all I have stressed the necessity for production engineers to widen their scope and take material handling more definitely into their consideration. In that scope I include external transport to and from the company and also the packing of its products.

Secondly, I have tried to show how many sections of a company can benefit by good material handling. Its scope is much wider than the majority of other individual techniques.

Thirdly, I have tried to encourage greater cost analysis of handling problems as a basis for improvement. In this cost analysis I include the setting up of a variety of control figures or ratios which, if published, would do much to stimulate competition and increase efficiency.

Finally, study the Anglo-American Report fully. It is full of good stuff by good men.

And once again, don't forget our slogan :

Production is Material in Motion

METHOD, MOTION, TIME AND MATERIALS HANDLING

by W. JAMES WEBB, A.M.I.Mech.E., A.M.I.Prod.E., A.M.I.I.A.*

FOR a long time I have been intensely interested in and closely associated with the subject to be considered. If its treatment is to prove of value, it must necessarily cover the widest possible field, leaving the details of application to their proper sphere in the textbooks, of which there exists an embarrassment of choice, although principally of American origin.

Now, it will be appreciated that in any enterprise engaged in the manufacture, processing or distribution of commodities essential to modern civilisation, we are at once faced with three fundamental elements—*method*, *motion* and *time*. The intimate balance of these elements determines output, production cost and, finally, the purchasing power of wages. For most of us this may be translated into the standard of living we can enjoy.

IN LIGHTER VEIN

Whether time study can materially improve the nation's living standard is a moot point. Slicing split seconds off the cycle time of an unskilled packaging operation is one thing: saving time on intricate operations involving weeks of processing is quite another. However, many laymen have not the slightest conception of what is meant by time study, and it depends on what source one approaches for enlightenment, as to what viewpoint one ultimately accepts. One may go to the all-scientific exponent or, according to taste, the satirist writer who treats the subject in lighter vein. Such a one is Mark Spade who, in his book "How to Run a Bassoon Factory," published by Hamish Hamilton in 1934, displays a keen insight into the mysteries, rites and traditions of contemporary manufacturing enterprise.

Quoting from the chapter on "Time Study and Costing," we find the following gem not entirely, as Mr. Churchill once said, "a terminological inexactitude":—

> 'You may remember that among the necessary experts I included a time-study man. It is his job to find out how long it takes a man to produce a bassoon, and, accordingly, how much you should pay men for producing it. He proceeds something like this:
>
> (1) He sets a man to work on making a bassoon and times him to a hundredth of a second. This gives him a figure to work on.

* *Presented at the Mechanical Handling Exhibition and Convention, Olympia, June, 1950.*

(2) He then takes his figure and applies the following reasoning:

(*a*) It took old Sam two days to make that bassoon, but he wasn't working as hard as he might.
Therefore divide by two=one day.

(*b*) Anyhow old Sam *is* old and not representative.
Therefore divide by two again=half day.

(*c*) On the other hand old Sam has had a lot of experience.
Therefore multiply by two=one day.

(*d*) But there were seventy-nine periods of two minutes when he didn't do anything.
Therefore subtract 158 minutes=five and a half hours.

(*e*) But he'll get tired later in the day, so we'll allow him half an hour.
Therefore add half an hour=six hours.

(*f*) On the other hand if the rate is too tight old Sam will kick up a row.
Therefore multiply by two=one and a half days.

(*g*) Anyhow we always leave a bit of margin so let's call it TWO DAYS.'

Mark Spade takes much the same line with costing, which is to many—particularly the unfortunate consumer—like a trip into the land of Einstein. How it must puzzle the ordinary man that a radio set costing from sixty to eighty shillings in material and labour, jumps to something more than twenty pounds when he seeks to transfer it from a shop window to his lounge.

On this subject, again quoting, we find :

'Costing is the way in which you find out why things cost too much. There are several sorts of costs :

(1) Material costs.
(2) Labour costs.
(3) Distribution costs.

If these are added together and subtracted from what a thing *actually costs*, we get :

(4) Overhead costs.

'The following is a practical example :

	£	s.	d.
Wood for bassoon			4
Metal for bassoon			5½
Reed for bassoon			½
Making bassoon		7	6
Total ...		8	4
Actual total cost of bassoon	29	9	6

	£	s.	d.
Therefore overhead costs (lighting, heating, office staff, rent, rates, directors' fees, experts' salaries, sales staff, insurance, assurance, loss on canteen, money stolen by cashier, loss on investments, depreciation of plant, etc.) ...	29	1	2

'To be perfectly frank with you, I don't want to go too deeply into the matter of costs, for I'm afraid you might get a little lost, and we don't want to play babes in the wood. But I can outline the general principles very briefly :

(1) Never worry much about inessentials like buying the stuff and making the bassoon. They hardly cost anything. On the other hand you can't have really modern production methods and science and things without paying for them.

(2) As long as you make enough of anything you can give it away, or pay people to take it, and you'll still make a profit.

(3) Don't be surprised if your costing department tells you one day that a thing costs twenty pounds, and the next that it costs four and threepence. Costing departments always do that, and they will certainly be able to produce figures which prove abolutely conclusively that they were right on both occasions. Anyhow, they probably were. It's just that there are several ways of looking at costs. Avoid the way that involves looking two ways at once. It is confusing and leads to strasbismus.

(4) Remember that the ways of Providence are strange, and that since accountants are the only men who are really closely in touch with them, it doesn't get you anywhere to question their decisions. Accept the fact that a thing which cost you seven and six in materials and labour was a dead loss when sold for twenty-five pounds, gracefully. If you have that sort of accountant you will probably find that it all works out all right in the end.'

FUNDAMENTAL CONDITIONS

So, to resume in more serious vein our examination of scientific aids to productivity in relation to mechanical handling:

There can be no controversy on the necessity for efficient methods, motion economy, time standard and planned materials handling. Wherever the repetitive nature of the product allows, we should make the fullest possible use of *all* these scientific aids to productivity. When conditions are such as to permit flow production technique, such aids should be applied with vigour and foresight. Where flow production is not possible, the least costly and most effective means of raising productivity is, without question, planned materials handling.

Unfortunately, as most supervisors and foremen know, British industrial capacity is in the aggregate made up of smaller production

units employing less than fifty workers. In many of these units, the nature of the production is *non-repetitive*, i.e. whilst conforming broadly to type and character, such manufactured products are in part 'tailored' to suit special requirements. Due to the individual features considered by customers to be necessary, it is impossible to achieve more than a limited measure of standardisation. This in turn restricts quantities to very small lots.

Under such conditions, it is manifestly absurd to attempt centralised planning together with time and motion study. In the absence of the prime factor—*quantity*—both techniques merely increase indirect expense resulting in an unnecessarily costly product.

SENSE OF PROPORTION

Scientific aids to productivity can be effectively employed only when conditions suitable to their application can be instituted. There must be proper regard to the economic principles upon which all industrial activity is based. This applies very much to time study, often used when good ratefixing would prove more suitable to the type of production technique, and the nature of the product.

Generally speaking, there is a far wider field for the application of ratefixing than of time and motion study in Britain. That must inevitably hold good until the traditional emphasis on the production of *capital goods* and *equipment* gives way to the American idea of consumer goods, such as cars for *all*. It must be remembered that American manufacturers have for long concentrated on the home market as a basis for the quantity production of low cost products. Britain, on the contrary, has mainly directed her industrial activity in the direction of capital goods, which are not sufficiently *repetitive* to permit full exploitation of intensive tooling methods or time and motion study: either of which require *standardised* conditions before the maximum economies can result from their use.

The foregoing does not in any way detract from the rational and beneficial application of time control, improved methods or motion economy in *most* industries including those employing a small number of workers. The objective, however, must lie in the direction of improved methods, the widespread adoption of simplified handling, a reduction of the fatigue factor, with the ultimate aim of so raising productivity that *basic wages* will increase proportionately to the rate of output throughout industry.

It will be appreciated that this is quite opposed to the accepted idea of maximum individual *earnings*, but in any event, only an aggregate increase of productivity throughout an industry could lower costs, increase basic wages, raise purchasing power and stimulate consumer demand.

Or. No.	Dept.	DESCRIPTION OF OPERATION	Tools & Gauges	M/C Class	Setg. Time	Time Allowed	Labour Grade
20	Inst:	Drill 4 holes marked 'D' .242" dia through side of legs (1 hole per leg) using a Letter 'C' Drill	Letter 'C' drill	Bench Drill	5 min	5 -	M.1
		Lightly countersink holes .015" at 45°	Countersink				
20	Inst:	Drill the following holes in underside of Base to the depth given, using Drill Guide Plate.	Drill Guide Plate	Bench Drill	5 min	8 - 50	M.1
		4 holes marked 'D' .242" dia to depth .875" using a Letter 'C' drill					
		1 " " 'T' .194" " " " .625" " a No.10 drill					
		4 " " 'U' .194" " " " .700" " a No.10 "					
		Lightly countersink holes .015" at 45°	Countersink				
22	Inst:	Spotface 10 holes marked 'A' .750" dia on underside of Base	½" dia facing cutter & bar K & W Fert		5 min	7 -30	M.1
23	Inst:	Locate Drill Guide Plates machined edges of Base	.375" drill	Drill			
24	Inst:	Drill and ream 24 holes to .375" ± .0004 dia	.375" Reamer with lead				
25	Insp:	Remove burrs from all drilled holes	gr 2nd op.	Bench		25 -	M.4.
		Inspect positioning and diameters of all holes drilled in Base on operations No.s 17 - 19 - 20 - 21 & 23.					

Material Spec.	Qty.	Finish Spec. No.	Impregnation Spec. No.
Al: Alloy B.S.S. 702	Ft. Per 100 / Lb. 100		

Sheet 5 of 7 Sheets	Title	Issue 1	Issue 2	Issue 3	Issue 4	Issue 5	Issue 6	Used on
Drg. No. 8017/20		Planner		Rate Fixer		Approved		

Fig. 1. An example of layout for a works running batches up to fifty. Times are based on machine speeds and feeds, all data and synthetics are internal.

RATEFIXING Most ratefixers graduate from the ranks of machine, bench hands or process operatives and are usually men of high practical skill. In spite of these qualities, however, they lack in many instances adequate knowledge of ratefixing technique; perhaps because there are no schools for the teaching

of practical ratefixing superimposed on an adequate educational background.

To illustrate the deficiency to be observed in the training of ratefixing personnel, it is proposed to quote J. J. Gillespie, a well-known consulting engineer whose findings are based on an investigation he carried out and related in his book, "Engineering Reorganisation":—

'*Examples of inadequate technical knowledge resulting from questions put to twenty-eight ratefixers and eight process engineers in nine different works:*

1. Not one could produce tabulated data in daily use to cover cutting tools.

2. Only two possessed data relating to metal tensile strength and/or Brinell.

3. All put much the same fatigue allowance on the job whether the operation called for manual effort for 100 per cent or 25 per cent of the operation time.

4. Only seven were able to handle effectively the setting of rates on machines, two or more of which were worked by one operator.

5. In only two of the nine works were machine capacity charts in use.

6. Only one of the nine works used constants, and in this case these constants were few and of little real use.

This investigation reveals a lamentable state of affairs and may well be a pointer to the low standard of industrial relations in some works, where ratefixing lacks the confidence of machine and bench operatives, so causing an effective brake on productivity, rather than a means of promoting confidence, stimulating effort and lowering costs.

Between ratefixing of the lowest order and the opposite extreme of highly specialised time and motion study lies the middle path of synthetic ratefixing by the comparative method. Scorned by the ardent time and motion study advocate, it has proved nevertheless to be adequate for the greater part of British industry, where highly repetitive production techniques cannot be applied. Before passing on to synthetic ratefixing, it would be well to take just a broad glance at time study *in extenso*.

TIME STUDY In many small engineering and other shops one frequently hears derision heaped upon the practical works-trained ratefixer, but it is nothing compared to the wholesale contempt reserved for the time study fanatic who—although a specialist on the Bedaux system—finds himself all at sea in a small factory, where the largest batch may be something less than fifty. Such an expert is likely to discover very speedily that he knows as much about shop practice as a mermaid about atomic fission.

WORK STUDY DEPARTMENT
OBSERVATION SHEET

Part No. 7070-6
Op. Turn and Face No. 1.

Elements	Pieces Studied						Analysis	
A. Pick up piece and Load to mandrel. oil centers and locate in machine.	80 75 75 80 70 75 22 24 26 20 28 26 80 80 80 81 70 70 21 20 23 27 27 27						80 22	29
B. Position tool for cut.	80 75 90 80 80 70 6 7 9 6 6 8 75 75 70 70 90 75 7 7 8 8 8 7						80 6	8
C. Face boss 2 cuts. 1 at .010" and 1 at .005".	80 75 80 80 70 65 18 16 18 18 21 26 80 75 75 75 75 80 18 16 16 17 17 19						60 18	24
D. Position tool for turning o/d.	80 80 70 70 70 65 6 6 8 8 8 9 80 80 80 80 80 65 7 6 6 7 7 9						80 6	8
E. Turn o/d to size 2 cuts.	80 75 80 80 75 75 18 20 21 21 24 21 80 75 75 80 70 75 20 21 21 20 26 21						80 20	27
F. Gauge with mic.	80 75 75 75 75 70 8 10 10 11 10 12 80 75 75 75 80 75 8 10 11 11 9 11						75 10	13
								contd...

Agree Machine is Set at most Efficient Speed & Production Rate is O.K.

Product: Type "X"
Component: Fixed Head
Material: Moulding Assembled.
Tools: Turning Mandrel.

Operators Name: Alexander
No. Section: 029
M.C Type & No: Bench Lathe
Batch Quantity: 50
Existing Rate: ·108 e/ch. Hrs Ew
Labour Grade: C
Observation Started: –
" Finished: –

N/Min per Piece = 2·830
Rest Factor 15% = All ·425
Std. Mins. Per Piece = 3·255
Issued As 3·25 Mins. Each
Man Hours Per 100 = 5·43 Hrs.

+ 20 mins. set-up

Observed By

Fig. 2. An example of a work-study observation sheet. Batches are from fifty to one hundred, but an economic batch is run if possible. For quantities under fifty, rating is by synthetics and comparison. For fifty and upwards, initial rating is synthetic and observation used for confirmation and, if necessary, adjustment.

On large-scale assembly such as radio, vacuum cleaners, packaging operations, chocolate enrobing and similar flow processes, where continuity permits a high degree of mechanisation, there is a legitimate field for the employment of time study in all its glory. In the majority of British factories—and the majority employ less than fifty workers—the time study man is a costly ornament, and his stop-watch about as useful as the home town clock to a traveller in the Sahara desert. Time study is an asset in the highly repetitive concern where materials, methods and machines are so organised as to produce "standardised conditions." Even so, there is still the "x" quantity, the *man* who so far has proved intractable to all the efforts made to standardise *him*.

Time study in fact claims to be so highly scientific that the field it embraces trespasses more than a little into the realm of medicine. If this appears to be an overstatement, then read 'Applied Time and Motion Study,' by Walter G. Holmes (Publishers: Ronald Press Co. 1938). This masterpiece of pseudo-scientific literature provides tables of neuro-biological reactions which, in simple language, means the time taken for impulses to travel from the brain to the various muscle groups via the motor nerves.

In another well-known textbook, "Motion and Time Study," by E. M. Barnes, one may find tables of oxygen consumption for various tasks involving the expenditure of physical energy. These tables naively conclude that a labourer consumes less oxygen in pushing a wheelbarrow at a normal brisk pace than during a slow walk or gentle run.

Let us take a glance at the brain reaction figures of Walter G. Holmes :—

TIME IN DECIMAL MINUTES

Nerve Reaction—Eye to Brain or Reverse	...	·0003	
,, —Hand to Brain ,,	...	·0024	
,, —Knee to Brain ,,	...	·0026	
,, —Foot to Brain	... ...	·0030	
,, —Realise Contact	... ...	·0010 to	·0040
,, —Hear or Smell	... ...	·0025 to	·0040
Mind decision —Mental Process	... ...	·0010 to	·0100
Finger-Hinge Movement—From Knuckle :		0 to 2″ × 5°	·0017
		0 to 4″ × 10°	·0021

RATE DEVELOPMENT SHEET

Department	029 Assembly	Date	24.7.46	Spec No	101
Product	Type X	Part	Fixed Head	Drg. No	7070-6
Operation	(1) Turn & Face	M/C Group & No.		P. Order No	
Labour Grade	C	Material		Tooling	
Speed	Top Speed	Feed	Sensitive	Lub.	Nil
Raw Material	7070-6a	Fin. Work	Op.2 Bench	Economic Batch	50

	Work Sequence	N/ Mins.	Per	N. Mins per		Std. Mins. Per
A.	Pick up piece and load to mandrel, oil centres, locate in machine.	29secs	1			
B.	Position Tool for cut.	8secs	1			
C.	Face Boss, 2 cuts, 1 at .010" at .005"	24secs	1			
D.	Position tool for turning O.D.	8secs	1			
E.	Turn O.D. for size	24secs	1			
F.	Gauge O.D. with micrometer	13secs	1			
G.	Finish turn O.D. (1 cut)	29secs	1			
H.	Deburr, Unload from machine, fit 7070-1 place in pan.	35secs	1		2.63	
				15%	.42	
					3.25	

Issued At	3.25	Std. Work Mins.	Equivalent Performance	18.5	Per Hr.	5.43	Per M.H. 100

Fig. 3. Rate-sheet used to establish standard time after use of the observation sheet.

Are we really to believe that time study experts are in possession of data on neuro-biological reactions which a handful of eminent medical specialists, scattered all over the world, have taken many years to obtain by painstaking research? Surely this is hardly conceivable!

Is Britain's ability to achieve economic stability dependent on her workers attaining a standard time of seventeen-thousandths of a minute to move a finger from the knuckle for two inches through five degrees, or, would we do better to rely on adequately training our workers, efficient management, good foremanship, alert supervision, not overlooking that quality of craftsmanship which once made British industry famous throughout the world?

What possible scientific or biological justification exists for the alleged standard measurement of human reactions? Practically every book on time study first oversteps the reasonable bounds of scientific veracity and thereafter becomes extremely unscientific by talking about "approximately" or "nearly." In precision engineering, a ten-thousandth part of an inch is accurate work which often causes many heartbreaks; yet, time study virtually blinds science by glibly claiming an accuracy of one ten-thousandth part of a minute for human brain reactions.

Most people would agree that in any industrial concern a fairly representative cross-section of men and women are to be found in all their diverse types. No two men are alike, each reacts strictly in character with type and temperament to a given set of circumstances. Those who write so lucidly about neuro-biological reactions should carry the pseudo-scientific jargon to its logical conclusion; they should explain precisely how the four basic human temperaments vary in their response, and what effect the state of the glandular system has on the so-called *standard nerve reaction times.*

It may be appropriate to suggest that some time study exponent with the necessary qualification will amplify these fourth decimal minute reactions, subdivided as between the four basic human temperaments—the *nervous*, the *choleric*, the *melancholic* and the *phlegmatic*. Each individual is conditioned by the endocrine glandular system, and each reacts according to type, to internal or external stimuli or conflicts.

Notwithstanding anything in the foregoing, there is undoubtedly a legitimate field for the application of rational time study, the operative word being *rational*.

Where process cycles or machine operations are principally *mechanical*; where conveyors, infra-red paint drying tunnels, pottery kilns or automatically controlled handling equipment are involved, there is definitely no legitimate field for time study. Improvements in process work of this nature can be reasonably expected to emanate from improved methods and to whom, if not

the production engineer, should one look for dynamic product engineering? If the time study expert feels himself capable of improving manufacturing methods, surely he should become a production engineer—Britain needs such men badly enough. Since the time study expert claims that *standard* conditions are essential for standard times, certainly his first duty is to help establish those conditions as a basis. It cannot sufficiently be stressed that Britain's industry must urgently exploit standardisation to the fullest possible extent.

The proper field for time study is in the reduction of non-mechanical cycles, i.e. in work of a manual nature, mainly of an unskilled character, or, where operators are specialists in a very narrow field—women on light assembly, in the clothing trade, provision and cereal packaging, in most of the luxury trades like cosmetic manufacture, pharmaceutical packaging and preparation. Within those fields where manual dexterity plays an important part and constitutes the larger portion of the production cycle, time standards are essential to the maintenance of standard costs. Where machine operations are concerned, there is little the time study man can do, provided the production engineer has processed the product with that efficiency one should be able to expect. If materials, machine speeds, feeds and tools have adequately been considered, any given equipment should be producing at optimum rate. Predetermined standards laid down by a production department can be very accurately computed by synthetics based on constants collected within the works where they are applied. On condition that such standards are supplemented by a plus tolerance figure (within the standard cost), there is little improvement to be anticipated from the use of the stop-watch. Were any such improvement demonstrated, it would be high time for a concern to find another production engineer or, alternatively, to offer remuneration commensurate with the degree of skill and training required by dispensing with the stop-watch department expense.

Britain needs dynamic production men with a good background of ordered practical apprenticeship plus adequate qualification obtained by means of a sound training in technology, economics and administration. Only when such a body of trained men are available and in a position to achieve a renaissance of British production technique, will it be appropriate to bring the stop-watch into action, where it is proved that efficient technology has failed to bring results.

TIME STUDY TO THE NTH POWER

If after very careful analysis it is found that the average size of British industrial concerns, in relation to the type of production, is suitable for all-out time study, let us by all means extend its use. In so doing, however, we must be prepared to justify its introduction by carrying it to its logical

DEPARTMENT		STANDARD SPECIFICATION No.	
PRODUCT 8" Speaker without Transformer.	PART Final assembly.		DRAWING No.
OPERATION As detailed.	TOOLING		OPERATION No.
MATERIAL	MACHINE GROUP	LAB. GRADE	WORKS ORDER No.
SPEED	FEED		DATE 17th December, 1943
STANDARD TIME 12.00 min	STANDARD WORK MINUTES PER Assembly.	HRS. PER 1000	No. OF OPERATORS IN SET-UP Eight.
COPIES TO SHOP FOREMAN; PRODUCTION CONTROL TO PASS TO COST OFFICE; PROCESS PLANNING TO RETURN TO WORK STUDY	ISSUED BY WORK STUDY OFFICE Studies by A.O. Travers		APPROVED BY FOREMAN

SHEET 1.

RAW MATERIAL. Adjacent to operators on bench.
FINISHED PARTS Stacked at end of Assembly bench.
OPERATORS. Team of eight.

OPERATIONS.

Operator.	Work Element	
A.	1	Assemble plate to housing.
	2	Rivet plate to housing.
	3	Fit panel by hand.
	4.	Rivet panel.
B.	5.	Fit 2 screws and nuts and secure with power driver.
C.	6.	Clean pole with air jet.
	7.	Clean magnet with air jet.
	8.	Clean assembly with air jet.
	9.	Place pole and magnet in position on housing assembly.
	10.	Fit 3 screws.
	11.	Secure 3 screws with power driver and hand driver.
D.	12.	Adjust magnet.
	13.	Select and fit cone.
	14.	Clean assembly with air jet.
E.&F.	15.	Paint rim of housing with Aretex.
	16.	Secure cone to housing.
	17.	Paint rim of cone with Aretex.
	18.	Secure felt to rim.
	19.	Wipe off surplus Aretex.

(Continued).

Fig. 4. Time-standard sheet used for the continuous belt assembly of a product utilising eight operators. Machined parts were made in small batches and rated by the comparative method to accommodate parts for other products. This is a reasonable field in which to apply rational time study, since assembly is mechanised and standardised.

conclusion—apply time study from top to bottom of any concern where it seems evident that increased production at *lower cost* will result inevitably from its introduction.

Prior to the installation of time study, it is of paramount imporance that :

DEPARTMENT ASSEMBLY SHOP			STANDARD SPECIFICATION No. A.84.
PRODUCT P.M. 8" Speaker without Transformer.	PART Final Assembly		DRAWING No
OPERATION	TOOLING		OPERATION No.
MATERIAL	MACHINE GROUP	LAB. GRADE	WORKS ORDER No.
SPEED	FEED		DATE 17th December, 1943
STANDARD TIME	STANDARD WORK MINUTES PER	HRS. PER 1000	No. OF OPERATORS IN SET-UP Eight.
COPIES TO SHOP FOREMAN; PRODUCTION CONTROL TO PASS TO COST OFFICE; PROCESS PLANNING TO RETURN TO WORK STUDY	ISSUED BY WORK STUDY OFFICE		APPROVED BY FOREMAN

SHEET 2.

OPERATIONS. (Continued).

OPERATOR.	Work Element.	
C.	20.	Fit two nuts.
	21.	Test and centre speech coil.
	22.	Stamp number.
H.	23.	wire and solder 2 tags.
	24.	Punch 4 holes in felt.
	25.	Magnetise.

Issued at 12.00 Standard work minutes per Unit.

Equivalent Standard Performance. 5.0 Units per hour.

LINE IS SET UP FOR 8 OPERATORS.

1.50 Standard Minutes per Operator.

Equivalent Standard Performance. 40 Speakers per hour from team.

(1) The type of product and its repetitive nature shall permit the use of standard methods, materials and even machines.

(2) A high degree of standardisation has been achieved so as to establish the degree of stability essential to the "standard task" as a reliable measurement of production efficiency.

(3) The sales volume of a product over a reasonable accounting period can be forecast with reasonable accuracy.

(4) The volume is sufficient to justify standardised methods, efficient tooling and job breakdown into elements.

The conditions outlined are the minimum for a manufacturing industry, but in packaging and confectionery production, etc., the field for the application of time study is much wider and the basic requirements less stringent.

Time study, even when applied to high-class product engineering, will not alone result in such savings as might be anticipated. Unless extended throughout an organisation, it is illogical to cut minutes off an operation time-cycle, whilst hundreds and perhaps thousands of hours are wasted on the indirect expense side. An analysis of such wasted hours spent in conferences, progress meetings, excessive paperwork preparation, and the vicious circles of high-pressure indecision often encountered, accounts to a great extent for the high selling price of many products.

Direct procedure, simplified routine and clear-cut designation of responsibilities would lead to less top-heavy administration from which British industry together with the government is suffering. If time study can truly make a worthwhile contribution to our economic salvation, then let us analyse the job of *everybody* concerned on the administrative side of an enterprise. How does the average executive spend his day? How many progress meetings does he arrange to ensure that subordinates—delegated and paid for a job—will not fail to discharge their responsibilities? Let us be sure that the irreducible number of executives and administrators are employed; that functions and duties are clearly defined; that such responsibilities as fall into the specialised class are delegated to *qualified* and *efficient* subordinates, who can be trusted to bring to light only such matters as may run contrary to a predetermined plan.

In short, let us be satisfied that every employee not engaged on productive work is assigned a clearly defined but *essential task* and that it is performed with the same standard of efficiency which time study aims to achieve in productive tasks. There cannot be two kinds of logic, nor can there be one measurement of efficiency for the manufacturing and another for the administrative side. If a *standard performance* is essential for manufacturing operations, it should be no higher than the corresponding standard for administration.

Many will retort that administration is *different*. What *is* the difference between an assembly operation comprising delicate manual handling and the man or woman preparing a material schedule? If the former can be measured in terms of a *standard task*, surely, there is no insurmountable problem in measuring the latter in like terms?

Looking dispassionately at time study, we find that it views all industries alike. It is not uncommon to meet with the same group

of " experts " engaged at different times in introducing time study in cotton mills, garment factories, engineering works and other widely divergent productive units. This may be an argument for the pure *scientific basis* of time study, but if so, there must be inevitably many gaps in the practical application of the theory.

INCENTIVES Incentives must be provided if productivity is to be increased and costs vigorously pruned. There is, however, one aspect relative to incentives which is nowadays either glossed over or completely ignored, i.e. the failure to provide incentives for those technicians who are responsible for evolving the basic conditions without which it is quite impossible to provide incentives for operators, much less to establish the fundamental conditions essential to greater productivity.

Think for a moment of the average engineering works where batch production is in being. The alpha and omega of the productivity potential depend almost completely on the ability of the planning engineer, who lays out the sequence of operations, decides the methods for good or ill and evolves in many instances the tooling, with proper regard to the economics of quantity.

Balance the incentives of such a man against those of the skilled and semi-skilled operator. In the first case, the average wage is about 25 per cent higher than pre-1939, and there are no bonus earnings on output. In the second case, there have been wage increases averaging 70 per cent, plus bonus earnings amounting often to 40 to 60 per cent of the basic wage. It is not unusual that the operative, for whom the work is planned and organised, averages higher earnings than the man who made such earnings possible, namely the planning engineer.

If this island needs greater productivity for survival, it must introduce more efficient methods, improved handling and incentives for the " back room boys." There is a long way to go before Britain has built up an adequate supply of properly trained production technicians. To do this, it is essential to keep in the forefront the elementary principle that, in this important field of work, incentives cannot be ignored. On the quality of her production technicians depends Britain's ability to hold even a subordinate position in international trade. Without production technique, there would be no work for operators ; no field for cost accountants ; no scope for management and no source of investment for capital either State or private.

Production technicians of the right calibre are difficult to come by these days. The reason is not obscure : there is no incentive to attain the necessary standard of education and experience, because the return for effort is often lower than that of the productive worker.

With all the talk of increased productivity, it is astonishing that so elementary a fact has escaped the notice of politicians, employers and even the Chancellor. Incentives to be equitable must be distributed proportionately to all who contribute to raising output, but special training and technical education must be justly recognised.

If time study could offer a solution to the problem of incentive for *essential* indirect personnel, it would render a service to the entire British nation : the operative word is *essential*.

A number of skilled craftsmen were recently asked, whether they would not like to become probationary planning engineers. The first question they put was relative to wages ; when told the amount, they one and all declined on the ground that they could earn more in their present job.

How can we expect to attract the best *practical* men who would be prepared to undergo further training in technology as potential production engineers, unless we offer reasonable incentive to compensate for loss of bonus earnings ? That this is a mistaken policy is quite clear, but where did such a policy originate, and who could possibly be responsible for such muddled thinking ? Incentives by all means, but to deprive industry of the right type of engineer by offering them less than they could earn on the machine or at the bench, is surely the height of folly.

None but the properly trained technician is capable of providing the conditions essential to the delicate balance of the three basic factors, *method*, *motion* and *time*, and linking them closely to the handmaiden of mechanisation—*materials handling*.

In the absence of the fullest comprehension of the urgency of those factors, our industrial technique will fail to blossom and the tree of economic progress will become sterile. It would be an inspiration to model a syllabus on a new concept of training designed to turn out technicians of a class comparable in status to that of the American production engineer. That would be at least in keeping with the march of time. Such men would, of course, have to be educated to appreciate the difference in the relative *quantity* potential as found in the respective countries according to their area. This is an urgent problem, since it is not any longer possible to escape the fight for a place in world markets.

MOTION ECONOMY

Motion economy, although generally thought of as an integral part of time study, is in reality quite separate and distinct. A little consideration will show that motion economy has much more in common with *materials handling* than with time study.

As the name implies, motion economy is directly concerned with the problem of human effort ; the elimination or reduction of

fatigue. Naturally, it cannot be denied that the primary objective of motion economy, is increased productivity. Unlike time study, however, motion economy is directed to *true labour economy* and the elimination or reduction of fatigue is a possibility in practically every industry, repetitive or otherwise. Hence, there is a very wide scope for the exhibition of motion economy which first analyses and then co-ordinates two of the basic factors mentioned previously, i.e. *motion* and *method*.

It may be said that motion economy, whilst broadly pursuing the same end as time study, nevertheless seeks to achieve its purpose in a rather subtle, but interesting and certainly more humane way. Humane, that is, if anything associated with the machine age, in the light of current economic policy, can be called humane.

The principles of motion economy can be stated under three divisions :—

(1) Reduction of fatigue in the usage of the human body.

(2) Location and layout of the work station.

(3) Design of tools, fixtures and work-handling equipment.

From these three classifications it will be quite clear why there is so intimate a link between *motion economy* and *materials handling*.

The two factors *method* and *motion* are of fundamental importance to motion economy or, as it is sometimes called, motion study. Indirectly, those two factors are closely related to the third, i.e. *time*. It will be obvious that method largely governs motion and that time is the resultant which, together with the sum of the variables, determines the labour cost of a given product.

Time, once expended, is beyond recall. It can, consequently, be concluded that any time expended in excess of what ought to be taken in performing an operation, handling or transporting material, must increase the cost of the product as inevitably as the taximeter ticks up the cost of waiting time.

Motion, by which we mean the movement of hand, feet or body associated with the performance of a manual task. In a broader sense, motion can also be related to the movement of materials, semi-finished and finished products during the various stages of processing, whether governed by manual or mechanical aids or a combination of both. In the widest possible interpretation, motion can be visualised as the means by which goods and materials are transported long distances *en route* to the consumer. All motion is relative in terms of time and hence in cost.

When considered in relation to a manual operation, a motion may be defined as a compound series of actions made up of a number of units of motion. A motion unit represents the smallest action which is measurable in terms of time—whether impulses from the brain, which cannot be seen, are to be included in this

definition is a moot point ; their exclusion will not materially affect the national economy.

Method is the term used to describe the *plan of activity* associated with the performance of a given task. It is the simplest, least laborious, most logical and generally the least expensive way of carrying out a process. The sequence of successive operations which go to make up a process are planned in an order designed to give the most economical result. The facilities, i.e. the tools and equipment, the feeding and disposal of material and the layout of the work station, combine to make the plan or method.

At this point it is appropriate to stress the role which ought to be played by foremen and supervisors. Their experience can find expression in devising the best method of performing a particular operation. Technical personnel should at all times draw on the experience of foremen and supervisors before finalising a plan of activity. There is a fertile field for the development of good teamwork where method is concerned. Supervision is, or should be, in intimate contact with operatives and it must not be concluded that the man who performs the operations is completely devoid of ideas on method.

Motion economy, then, will to a great extent depend on method, and for that reason can be applied to many tasks of a non-repetitive nature.

Very largely due to motion economy, it has been found possible to train blind and partially sighted persons for light assembly ; in certain circumstances, even for machine operations where special safety precautions have proved practicable. A great deal has been achieved in training blind or disabled people to perform useful work by the patient and human application of the principles of motion economy. In this connection, the layout of the work station, the predetermined location of tools and fixtures, and the fullest possible use of planned method, has contributed much to the success of the blind and disabled in performing operations normally done by sighted and able operatives.

Motion economy rests on the basis of eliminating movement, reducing the extent of movement and in ascertaining the combination of movements which will give the most economical and least tiring sequence. The position of the operator, work bench, machine, component trays, bins, conveyors and the relative dimensional layout will ultimately determine the expenditure of energy and the cost of performing a given operation. The sequence of using materials and tools should be so arranged that the cycle of movements passes from one side to the centre of a working area, conforming as closely as possible to an arc or semi-circle.

The principles can be applied with equal facility to bricklaying or bootmaking, hairdressing or hamcuring, and the more manual

labour involved the wider is the scope for motion analysis. It should also be said that the greater the need for reduction of fatigue, where heavy labour is concerned, the greater is the need for mechanical handling.

There are certain principles governing motion economy most of which are equally applicable to materials handling :

Work Stations

(1) Fixed stations for all tools and materials should be provided.

(2) Controls, tools, components and materials should be situated as closely as possible to the front of the operative.

(3) Gravity feed trays, bins or containers should be utilised to deliver material or components as closely as possible to the assembly or usage point.

(4) " Drop deliveries " or magazine feeds should be employed on every practicable occasion.

(5) Tools, components and materials should be located to permit the use of the best, least tiring and most economic sequence of movements.

(6) The height of tables, machines, equipment and appliances should be arranged with a view to the easiest accessibility and least fatigue.

Tools and Equipment

(1) The hands should perform only such work as cannot be more advantageously performed by the feet or other parts of the body.

(2) Wherever practicable, two or more tools should be combined as a dual purpose appliance.

(3) Tools, materials and equipment should be as far as possible in predetermined locations.

(4) Control levers and hand wheels should be located in positions that permit easy manipulation by the operator. The objective is to operate such controls with the minimum change in body position and the maximum mechanical advantage.

Compare the foregoing principles with the questions the production engineer must ask himself as a preliminary to planning a materials handling installation :—

(1) Can the number of times the material is handled be reduced with properly designed equipment or appliances ?

(2) Is it possible to reduce the distance the material must be moved ?

(3) Are suitable bins, containers or trays used for receiving, storing and moving the materials ?

(4) What delays are experienced in the delivery of material to the operator or processing point ?

(5) Can the operator be relieved of manual materials handling by the use of conveyors or other equipment?

(6) Is the existing equipment the most suitable and economical for the work?

(7) Are ample facilities provided for the maintenance of all equipment in a condition of safety and efficiency?

The close relationship between motion economy and material handling can now be seen clearly, this being ample justification for stressing the complementary character of the two as a means of raising productivity.

The importance of *motion* and *method* will become all the more evident when expressed in a single sentence, such as the following:

Time involved in the unnecessary transport, protracted handling or prolonged storage of raw material, semi-finished or finished products is often the main single source of loss in industry.

A parallel statement could be made regarding plant and equipment:

Idle manufacturing plant, machinery and handling equipment represent time in which a part of the invested capital lies idle.

Loss from either of the above causes is reflected in lower total turnover, i.e. in the numerator of the ratio

$$\frac{\text{Indirect Cost}}{\text{Direct Cost}} = \frac{\text{Numerator}}{\text{Denominator}}$$

Direct costs relative to any department will always be directly proportional to production volume, but the numerator is unlikely to conform to any such precise mathematical ratio. As will be appreciated, the least controllable factor in the ratio is the numerator, and the sources of serious leakage are to be found in the items under materials and plant. These factors could be reduced to a minimum by foremen and supervisors willing to develop "cost consciousness."

Far bigger dividends are likely to accrue from a considered application of the principles of motion economy and materials handling technique than ever could result from the extended use of time study.

RATEFIXING TECHNIQUES AMPLIFIED

It is customary for exponents of scientific management to laugh at the comparative method of setting a rate. Is there anything very funny in comparing a particular job with a similar one already being rated? Bearing in mind that the major part of British industry is not highly repetitive, it is a fair question to ask: "What is the sanest and least expensive method of rating from one to ten similar parts?"

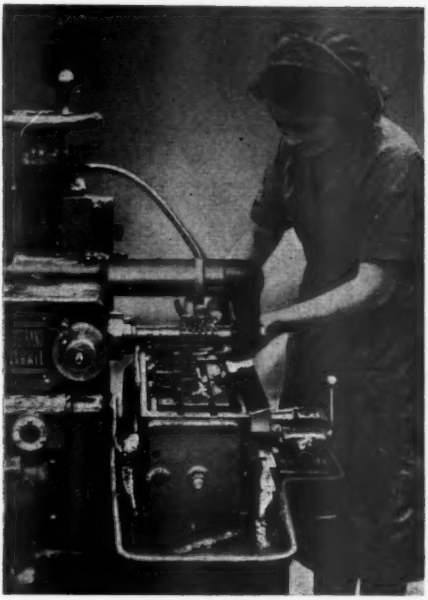


Fig. 5. Quantity production of small tools-milling dies for die-heads. Machine tools are permanently set and conditions highly standardised. Time study is not used for rating.

Comparative ratesetting certainly has many weaknesses, the principal being the possibility of multiplying previous rating errors. This important weakness can be eliminated by breaking down operations on standard sheets and taking each element separately for comparison. All such standard sheets should, of course, be retained for future reference. Operation breakdowns need not be in infinite detail but just sufficient to reveal the *similarities* and *differences* between the two jobs under comparison.

The calculation method of ratesetting is extensively employed on sheet-metal cutting, forging and welding. When used in relation to machine shop work, it is customary to calculate times on the basis of speeds, feeds and depths of cut. Setting and handling times are by this method generally based on recorded experience.

Properly carried out, where capacity charts for the machines are available, the method is more economical, reasonably accurate, and certainly more sensible for very small lots than time or work study.

For larger batch work of from twenty upwards, the synthetic method of rate setting has much to recommend it. The advantage

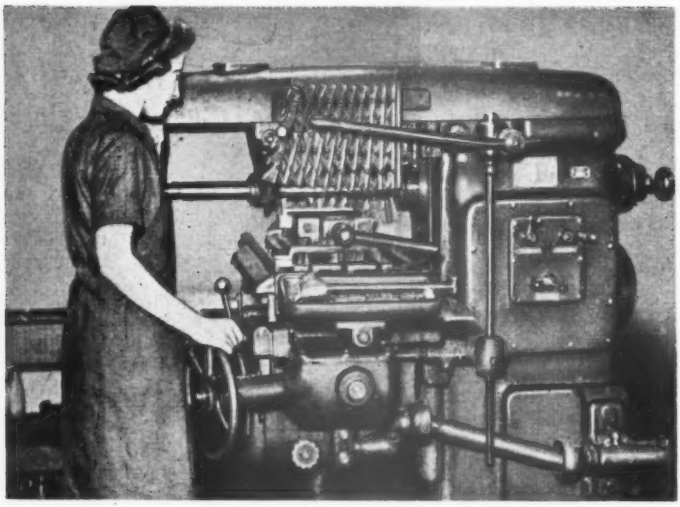


Fig. 6. Another operation on dies-slot milling.

of this method is that it can be used in combination with other methods.

Generally speaking, the synthetic method is based on constants collected by time or work study. In any case, all job rates are carefully analysed for recurring constants, which are extracted and filed under an appropriate heading.

Constants for preparation time, grinding, mounting and setting tools are easy to collect, as also are constants for general fitting, sheet-metal, welding, forging and painting work.

The fatal blunder of attempting to make use of constants collected by other people under different conditions is frequently made, and this kind of mistake can lead to serious troubles between ratefixers and operators. It is not uncommon to find synthetics and constants, collected under repetitive conditions, and large batch production, being applied in shops where batches of over fifty are the exception.

It should be self-evident, that to set rates on very small batches on the basis of "X" hours per thousand is likely to bring ridicule and distrust upon the head of the ratefixer or ratesetting department.

Furthermore, it will be abundantly clear to anyone with the slightest knowledge of ratefixing that, when such figures as "X" hours per thousand are specified, it is an incontrovertible fact that

the synthetics and constants were collected in some place other than that in which they are applied.

When synthetics and constants recorded under large batch conditions are utilised for very small quantities, the rates set will generally be too low. This will result invariably in adjustments having to be made either during or after the completion of the job. When adjustments have to be made in more than 30 per cent of all jobs issued to a shop, it is safe to assume that :

(a) the ratesetting is based on synthetics collected under conditions varying from those under which they are applied;
(b) the ratesetting department is incapable of handling the class of production ; or,
(c) lacks the qualified staff to collect and collate the essential data from the actual shop in which such data are to be used.

It must be remembered that large batch production is normally carried out under more stable and standardised conditions than is possible or economically advisable with short run production. So big is the variation in the synthetics of the two types of production that, in spite of adjustments before actual issue of a rate, there is an inevitable margin of error on the minus side. From a plant loading standpoint, these errors are on occasion likely to prove

Fig. 7. Drilling part of a crankshaft in a marine engine shop. There is no scope here for time or work study.

Fig. 8. Drilling in a heavy boiler shop. This is an example of industrial work in which Britain specialises, but the stop-watch would be entirely out of place in this type of works.

disturbing. If delivery promises are made on the basis of rate-fixed times, which eventually prove to be from 30 to 50 per cent low, any attempt at plant loading is rendered abortive.

In factories where batches of from five to fifty are customary, synthetic ratesetting can be very effective and is the least costly. This method is well worth the initial expense of collecting the data in the shop in which they are to be applied. If that is done efficiently, there will be a sound basis for plant loading and progress. Reasonably exact ratesetting is a prerequisite of effective production and cost control, as well as a means of accurate estimating for the purpose of tendering.

SUMMARY As a result of the various points made in this paper, many of which are controversial and provocative, it is hoped that the interest of foremen and supervisors will be so aroused that they will develop their own line of thought on the many problems and seek, find and apply their remedies. The solutions may vary in nature, but provided they do not materially depart from basic principles, more good than harm will result from different ideas. Teamwork also counts considerably, and

what better teamwork could there be than a gathering of foremen and supervisors, stating, discussing and solving their manifold problems ?

There is one further aspect of job rating which needs to be made clear, whether the method of rating is by means of time study or ratefixing, i.e. the *lack of uniformity* in different factories, even in those where similar products are manufactured.

Time study or ratefixing is intended to be a standard of measurement for the purpose of accurate costing and as a means of assessing efficiency. Unfortunately, neither time study nor ratefixing can be said to be adequately fulfilling their proper function.

Under existing conditions, there can be little hope of a uniform standard for a given operation or process as between various firms, because each evolves an individual system of allowances over the normal time for a given operation. There are such wide differences, therefore, in the standard times for similar operations, that comparisons of efficiency become virtually impossible.

Many firms do not use their job or operation rates as an efficiency measuring standard, but rather as a method of offering an acceptable wage level. To attain any standard of comparative efficiency, it would be imperative to standardise basic wage rates for similar work and abolish the practice of weighting time standards to suit wage policy.

As an example of this kind of policy : many firms recognise normal bonus earnings to be of the order of from 60 to 80 per cent, and operators in such firms often demand and obtain double time before they will even pick up a job. Such policy usually implies that wage rates are kept at the lowest possible level and that merit awards for ability are entirely lacking.

On the other hand, the existing principle has been clearly defined, i.e. that an average performance by an operator should permit 27½ per cent to be earned with the rating issued for the job. Under proper conditions, a good operator might be able to earn 40 per cent ; if returns should be higher, either the operator is exceptional or the method of rating unsatisfactory. How many firms in practice are in a position to operate under conditions of a minimum of 27½ per cent for average performance ?

Based on the text of this paper, the following conclusions emerge :—

(1) Time study can do little to increase productivity, except in highly repetitive or in the light industries, where females are employed, mainly on manual operations of an unskilled highly specialised nature.

(2) Time study is not complementary to materials handling ; the latter could alone appreciably increase production in most industries.

(3) Motion economy and materials handling *are* complementary, and applied together could contribute to a marked increase of output. Irrespective of whether an industry is non-repetitive, large or small, there is a field for doing things more easily and economically. Motion economy can lighten the fatigue of repetitive or non-repetitive work. Materials handling can lift, shift and transport liquids, solids and gases to any place required in a controlled time cycle. Some manual transferring is often necessary, but motion economy since it studies method will focus attention on the easiest way.

(4) Synthetic ratefixing based on speeds, feeds, depth of material removal, together with constants and data collected in the particular factory, provides all that is necessary in the majority of British works. This must be so since the majority of factories in this country employ less than fifty workers ; are neither highly repetitive nor in a position to offer the *standard conditions* which are essential to time study technique.

Fig. 9. Fitting cylinder head-studs in an engine shop. If the output of similar engines permitted standardised conditions, time study might be applied to this job. Comparative ratefixing for the stud-fitting operation on the batches of engines would be the most reasonable method of rating.

Fig. 10. *Another operation. Fitting connecting-rod and piston, after fitting studs.*

(5) Time study, in any case, is not generally applied as a standard of measurement, but rather as a method of bolstering up a low wage-earning level. *Standard times* are often increased by allowances under various guises, in order to supplement the basic hourly wage. Such allowances are generally called an incentive scheme, but it would be less expensive to adopt a simpler method of arriving at a reasonable incentive.

As a suitable ending to this paper, it might be appropriate to pose a question : " Why bother at all about time ? "

Some fifteen years ago, a story (later found to be authentic) was told of an industrialist who decided that time study and various scientific management theories had failed to give him the results he expected. Consequently, he started to blame himself for bad management and accordingly went to the other extreme by abolishing time study, time control and time clocks.

First of all, he divided his factory load into shop programmes with a target output for every machine and working group. He established a target delivery date for every job in the factory.

Next, after having removed time clocks, he informed the employees that in future he would regard every department as a team and pay them the highest wage rate in the area for their particular

job. In addition, he would give them a bonus for every hour saved against the target date. All men were told that he did not mind who took the afternoon off to go to the sports ground; that was up to the departmental team. They could do as they pleased provided the targets were met, and if they did not wish to earn the bonus for beating the target, well, that was their affair. No stoppages were to be made for time-off nor any disciplinary action taken unless requested by the committee in the department concerned. Do you think this seemingly crazy experiment resulted in chaos and bankruptcy? Far from it; output increased to a peak previously never reached. Production costs took a downward curve and all target schedules were handsomely beaten.

How was it done? For the first week or two, there was a fair measure of time-off due to the newly founded policy of freedom. It did not last very long before the shop committee exercised their own disciplinary measure. The lazy were soon either reformed or dismissed, at the request of their colleagues, who considered they were being victimised by the slackers.

This may not be an experiment to be recommended for universal adoption. It is clear, however, that the industrialist who made this revolutionary change must have possessed a remarkable insight into the complex character of mankind.

Perhaps, in this mechanical age, it might well be that a study of man, his longings, needs and aspirations, would pay richer dividends than an intensive research for new methods of prodding him on; or more original means of suspending the carrot before him.

These questions will all, doubtless, be solved in the passage of time. Meantime, the problem of producing enough to sell at a price our overseas customers are willing to pay is still with us and it must be solved if the nation is to be fed, housed and clothed.

The purpose of this paper is to offer a contribution to the solution of our economic problems. If it causes dissension, it will have adequately answered the end for which it was designed. It will then be up to the dissenters to evolve effective methods of solving the problem, the existence of which they will not deny.

It matters little by whom or by what means the difficulties are resolved, so long as Britain does not remain static, but continues on the march in step with progress.

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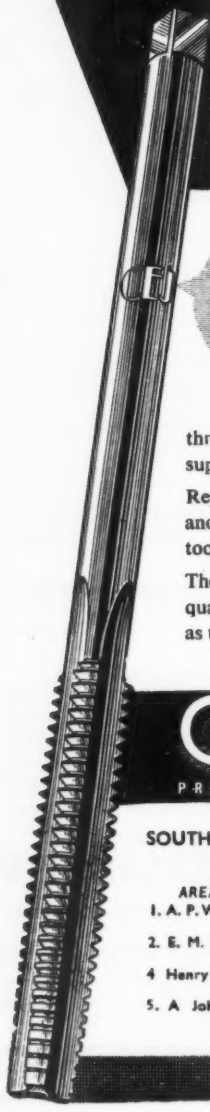

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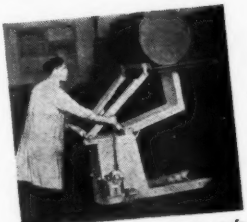

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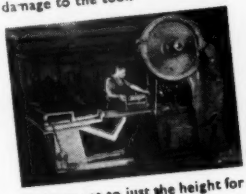

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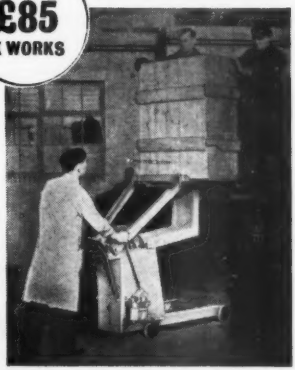

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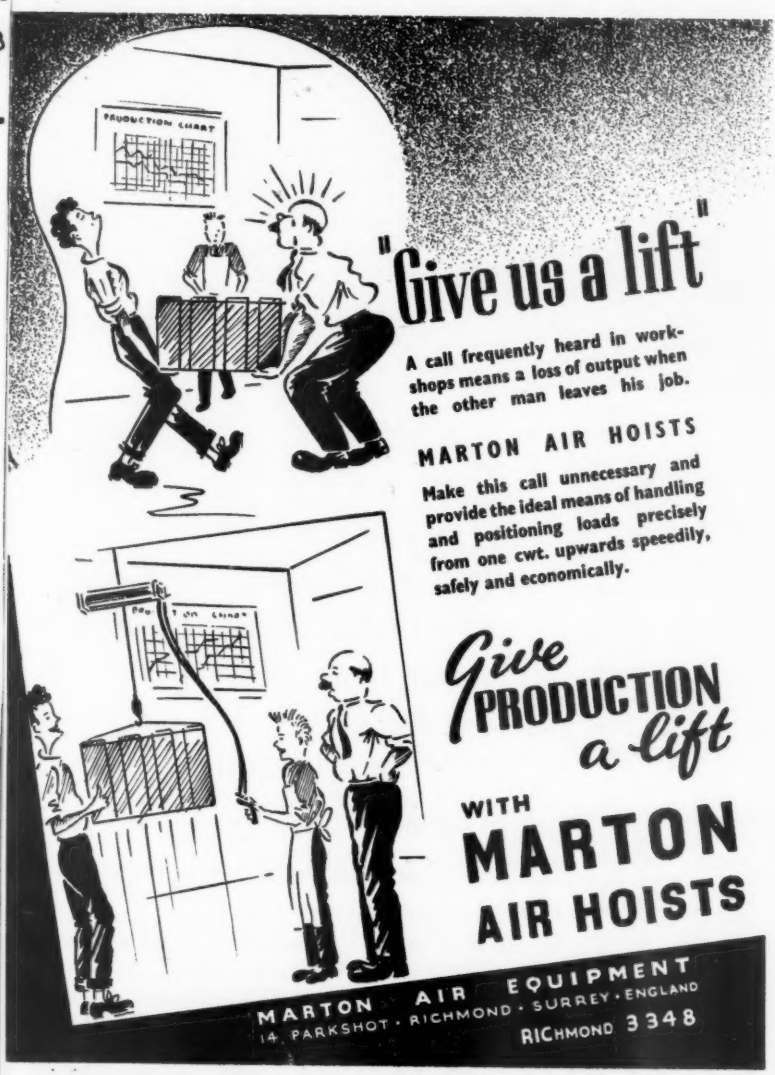
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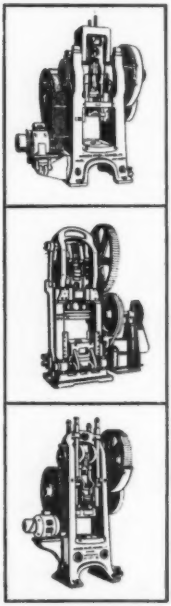

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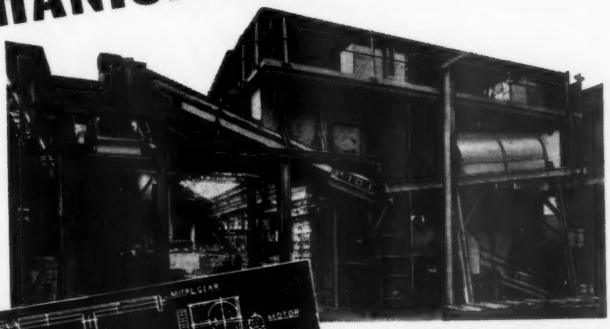

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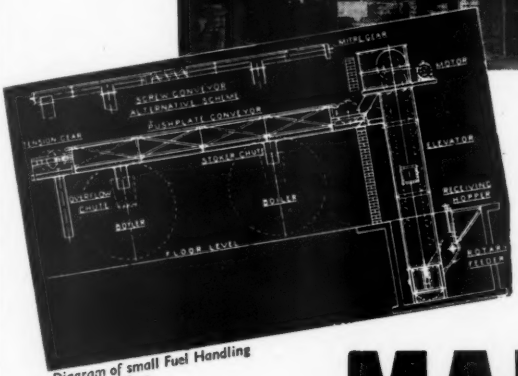

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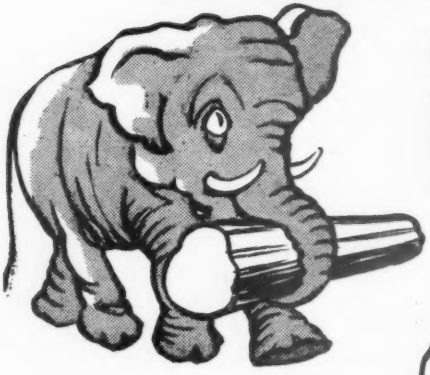

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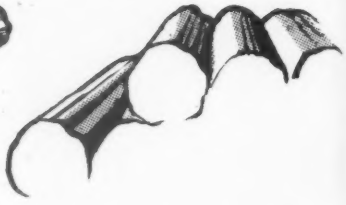

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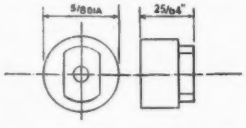
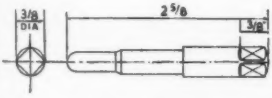


Clinch Nut—(Mild Steel). Operation: Mill flats. Output: 2,000 per hour.



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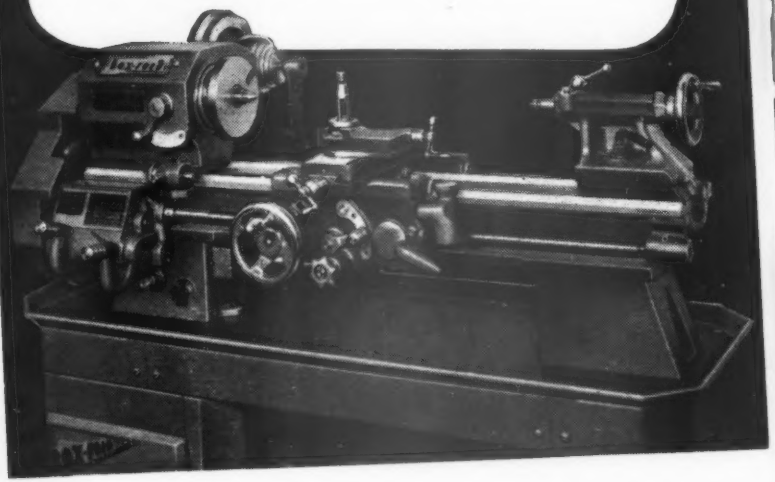

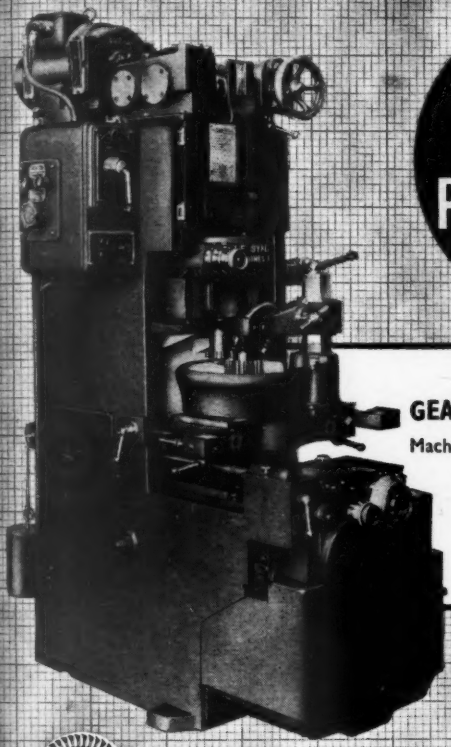

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Machine illustrated is the Sykes Vertical Gear Generator type V. 10A for spur and helical gears, external gears up to 14" diameter, internal gears up to 20" dia, maximum pitch 5 D.P., maximum face width 2¼". Accessories include a Rack Cutting Attachment for racks up to 24" long.

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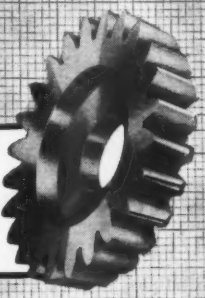

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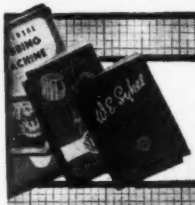

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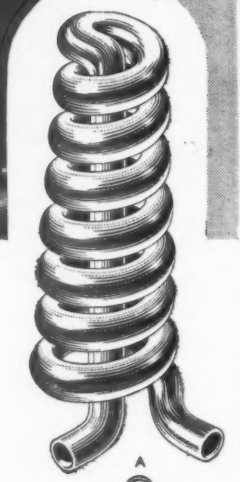

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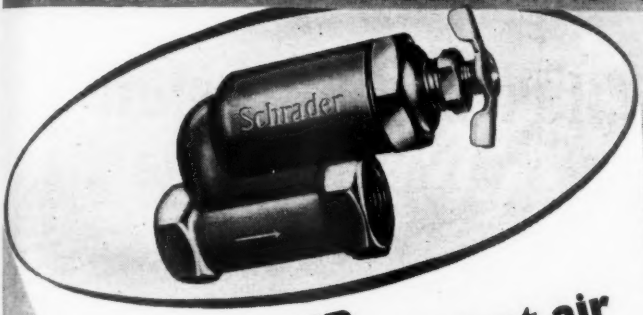

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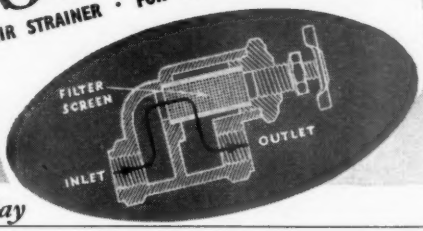

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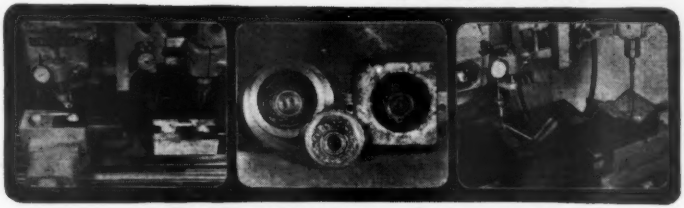
Further details of this machine and its application may be obtained on request.



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RESISTANCE: Up to 1 megohm.

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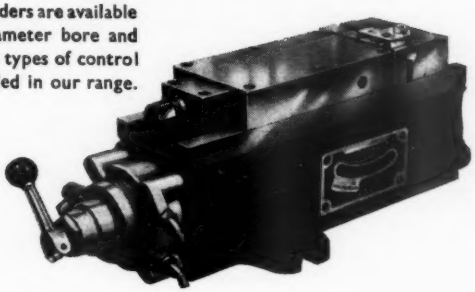

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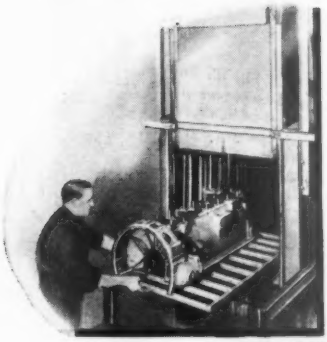

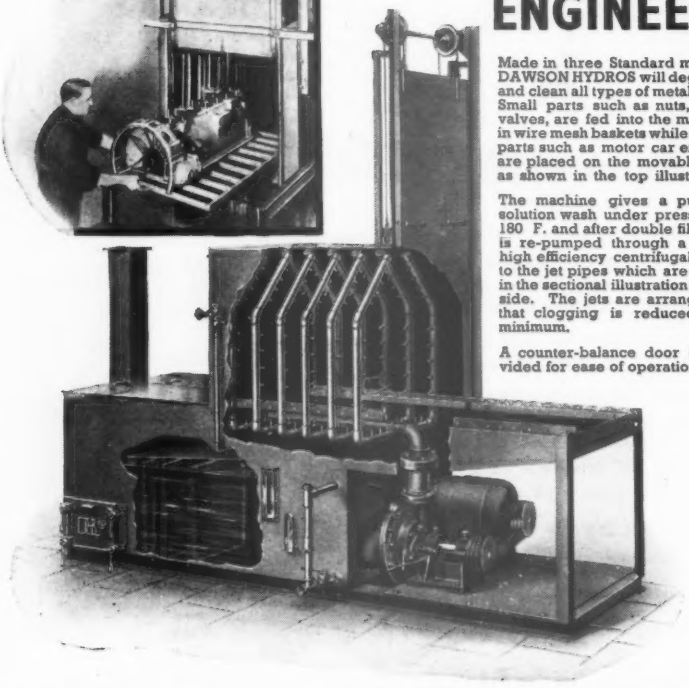

Made in three Standard models, DAWSON HYDROS will degrease and clean all types of metal parts. Small parts such as nuts, bolts, valves, are fed into the machine in wire mesh baskets while larger parts such as motor car engines are placed on the movable rack as shown in the top illustration.

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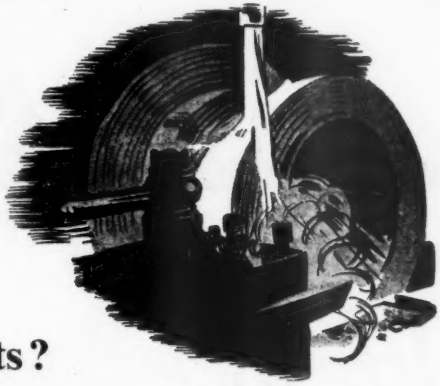

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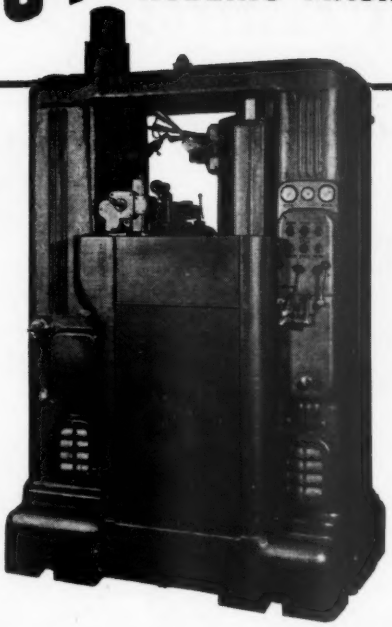

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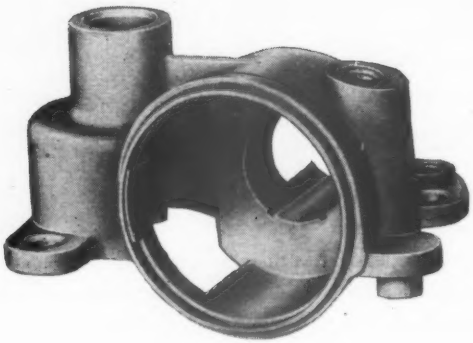

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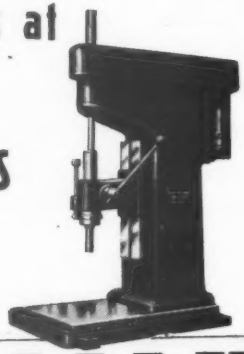

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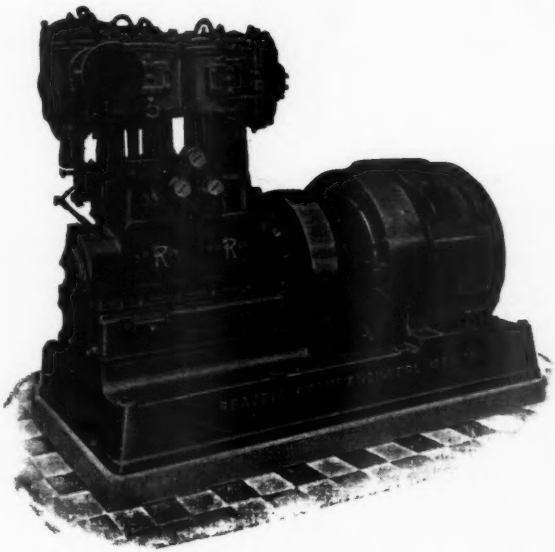

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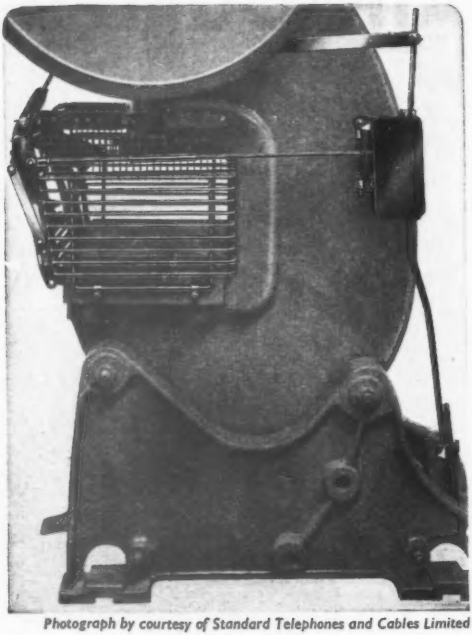

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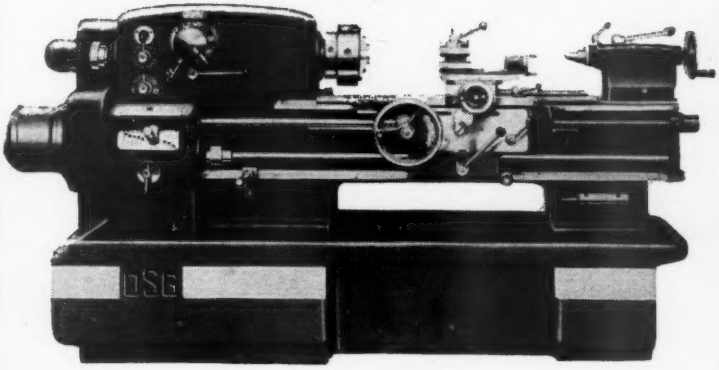

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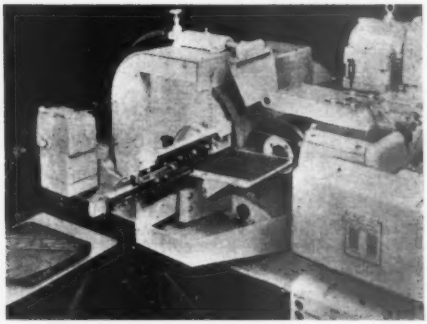

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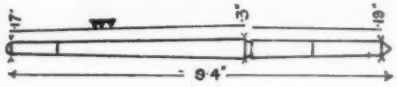

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MATERIAL:	1% Carbon steel.
MACHINE:	Scrivener No. 2 controlled - cycle Automatic.
OPERATION:	Plunge - grind on four tapers.
STOCK REMOVAL:	.010".
No. of CUTS:	2.
TOLERANCES:	To gauge.
PRODUCTION:	400 per hour each cut.

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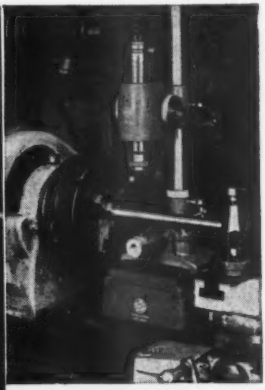

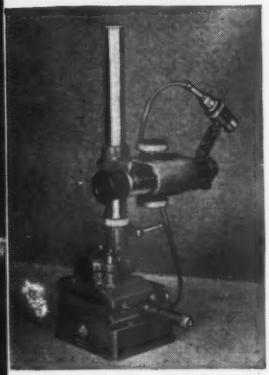

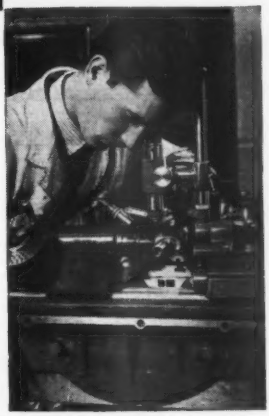

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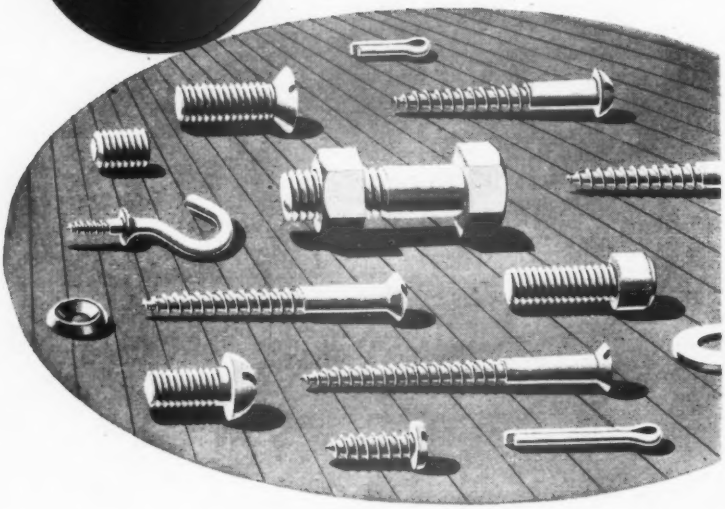

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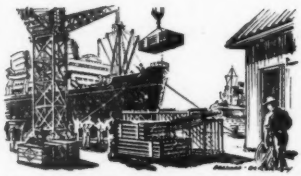

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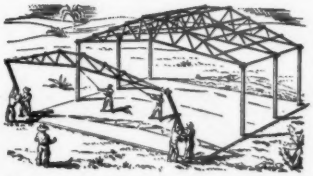

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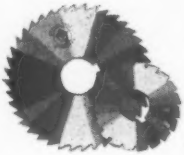

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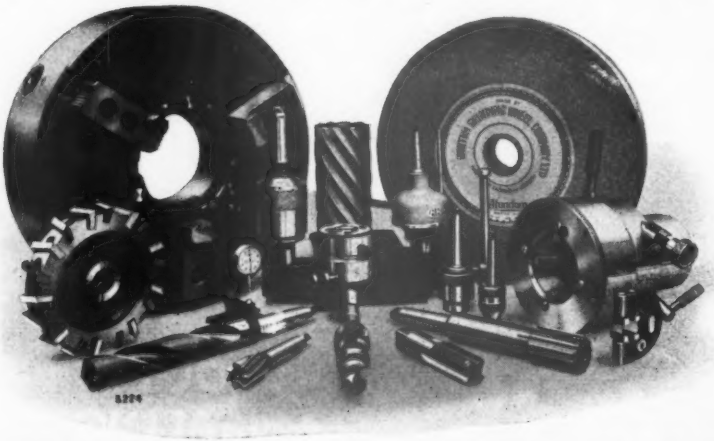

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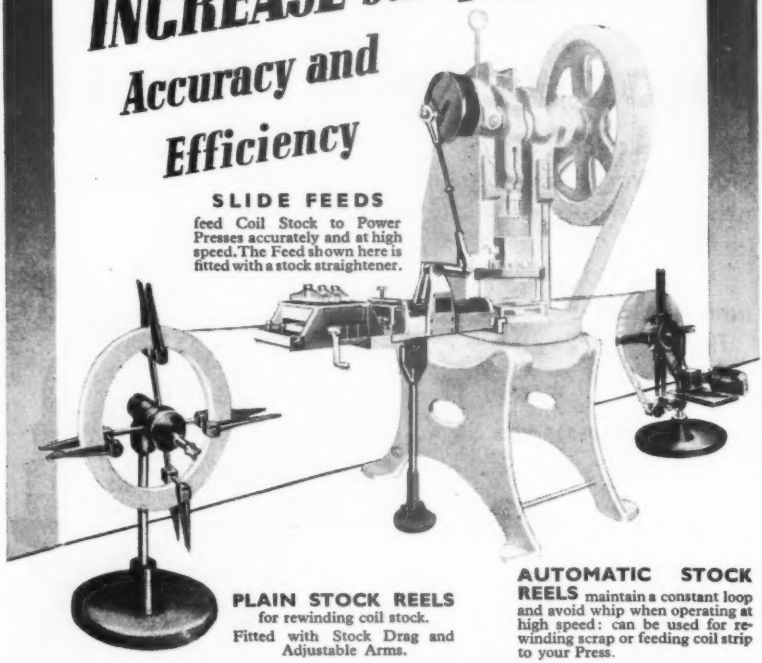

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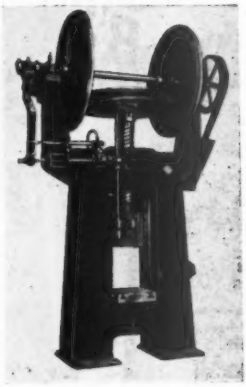

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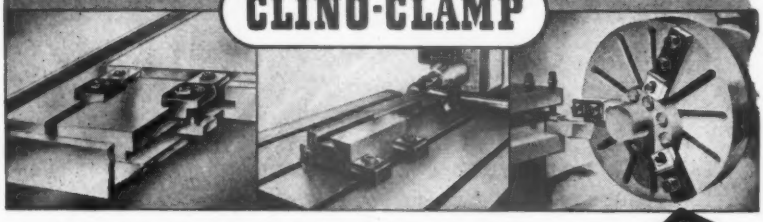

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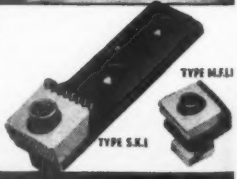

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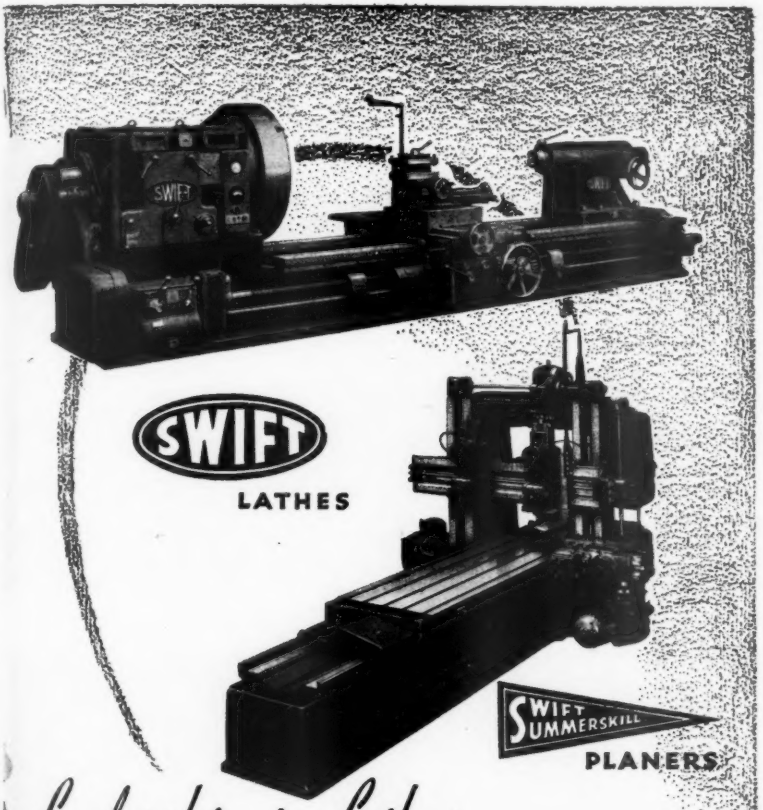

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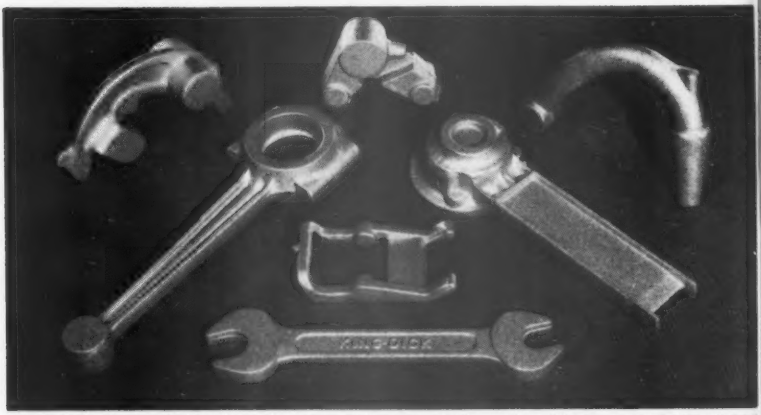

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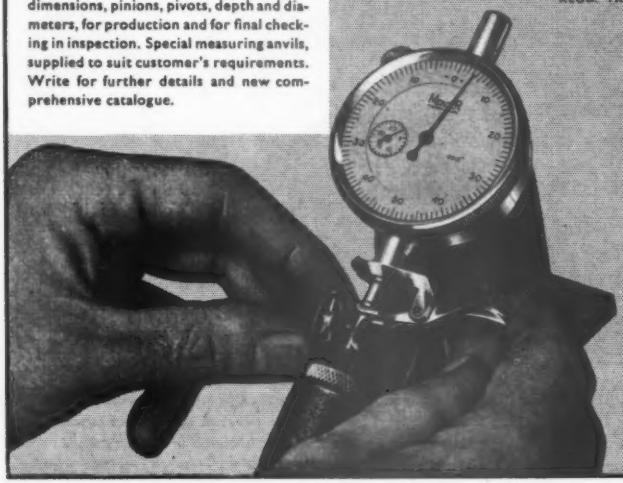

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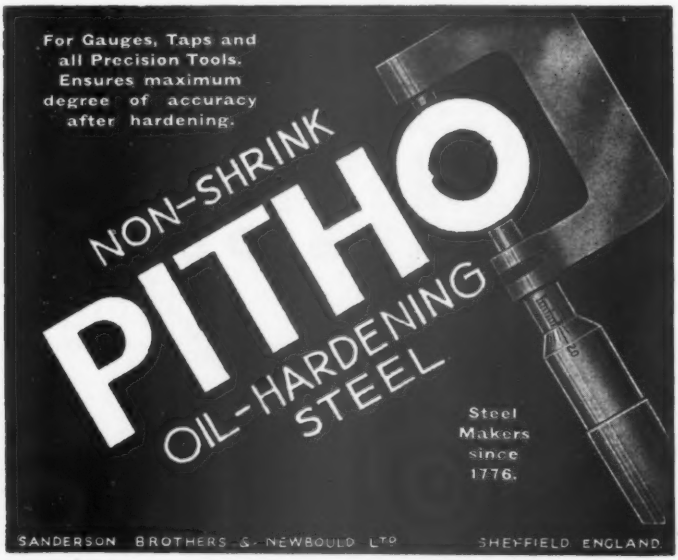
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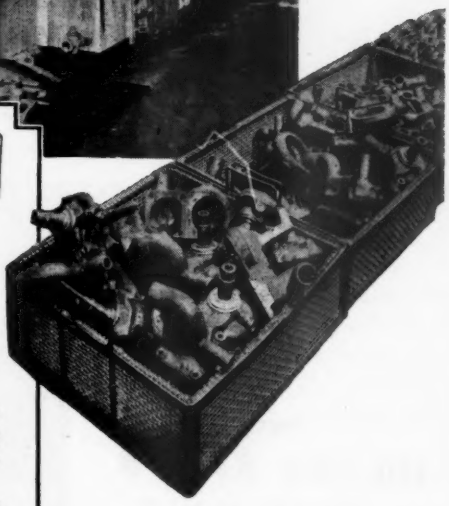

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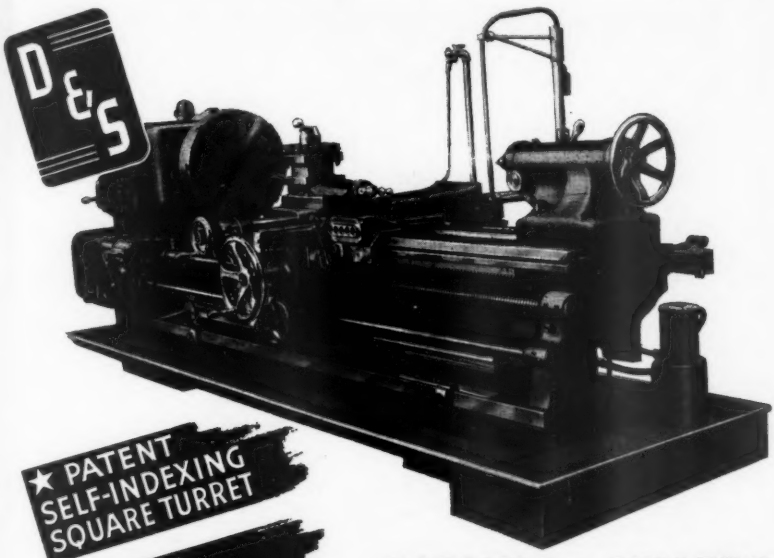

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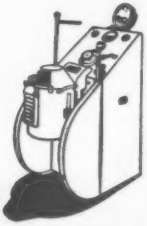

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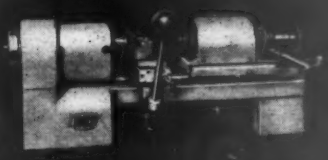

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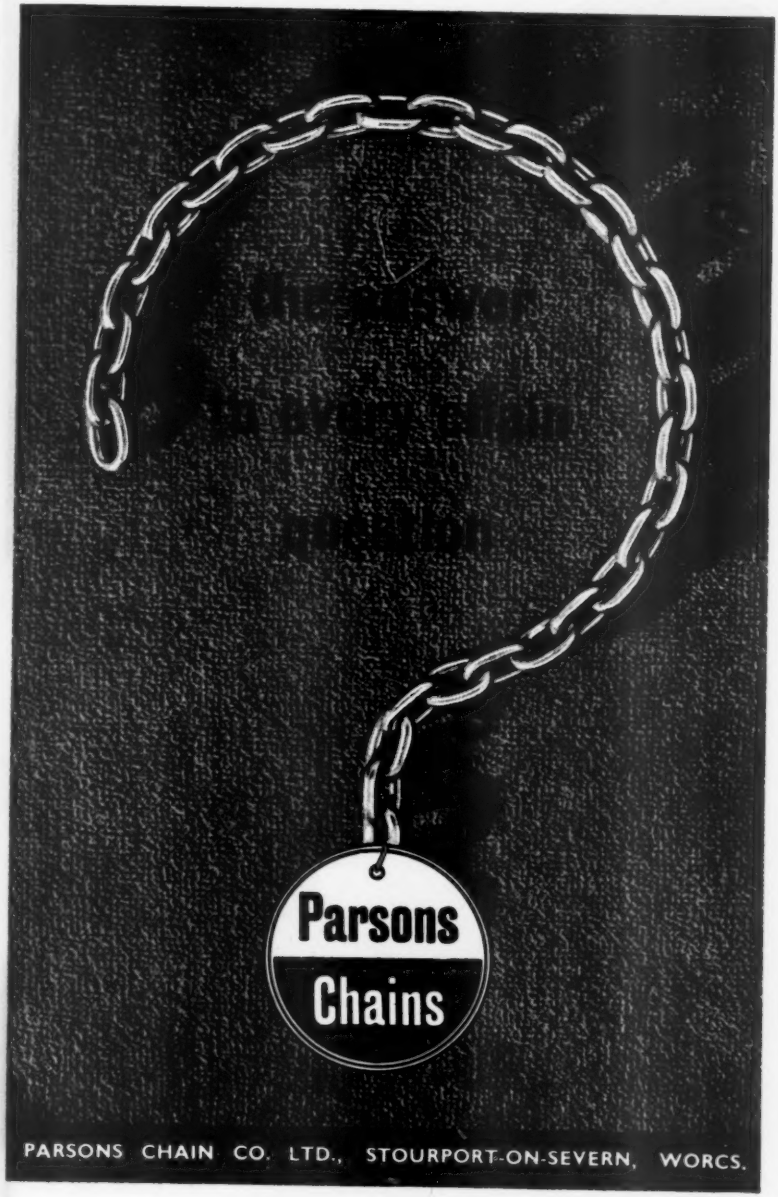
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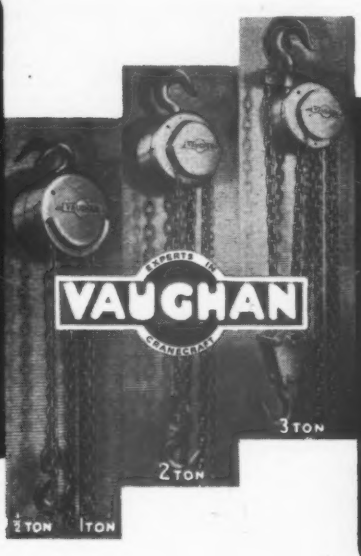

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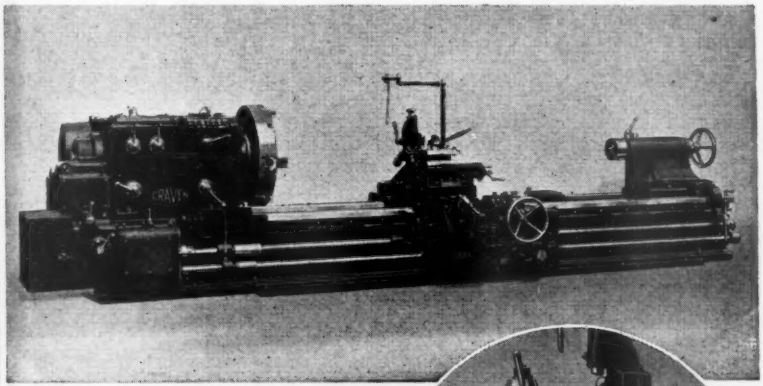

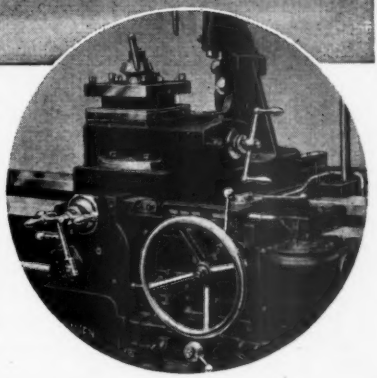

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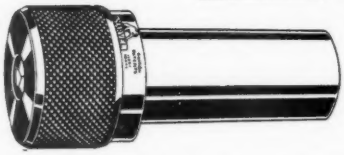

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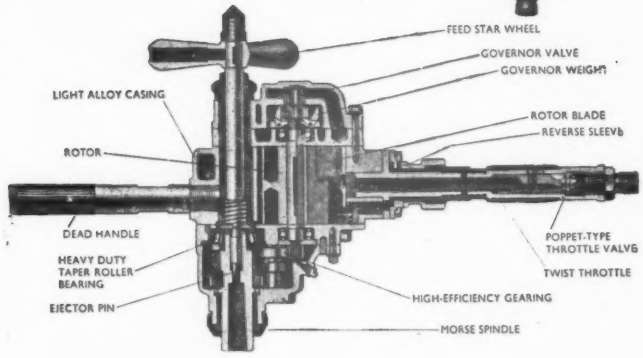

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